



**U.S. Army
Environmental
Center**

**FORT DEVENS
FINAL REMEDIAL
INVESTIGATION
FOR GROUP 2 & 7 SITES**

**FINAL
REMEDIAL INVESTIGATION REPORT
AREA OF CONTAMINATION (AOC) 41**

VOLUME I OF II

**CONTRACT DAAA-91-D-0008
DELIVERY ORDER NUMBER 005**

**U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MARYLAND**

DTIC QUALITY INSPECTED 3

February 1996

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REMEDIAL INVESTIGATION REPORT
AREA OF CONTAMINATION (AOC) 41**

VOLUME I OF II

**CONTRACT DAAA-91-D-0008
DELIVERY ORDER NUMBER 005**

Prepared for:

**U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland**

19970820 131

Prepared by:

**ABB Environmental Services, Inc.
Portland, ME
Project No. 07053-15**

February 1996

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PREFACE

In 1991, the U.S. Department of the Army and U.S. Environmental Protection Agency signed a Federal Facility Agreement under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act for environmental investigations and remedial actions at Fort Devens. The agreement required that Site Investigations be undertaken at each Study Area to verify whether a release or potential release of contaminants exists, to determine the nature of the associated risk to human health and the environment, and to determine whether further investigations or response actions may be required.

In 1991, Fort Devens was identified for closure by July 1997 under Public Law 101-510, the Defense Base Closure and Realignment Act of 1990. This has resulted in accelerated schedules for the environmental investigations at Fort Devens.

In 1991, under contract DAAA15-91-D-0008, the U.S. Army Environmental Center (USAEC) (formerly the U.S. Toxic and Hazardous Materials Agency) tasked ABB Environmental Services, Inc. to conduct Site Investigations at 13 Study Areas in Groups 2 and 7, and the Historic Gas Stations (19 sites), as described in the Fort Devens Master Environmental Plan (Biang et al., 1992). The findings of these site investigations are presented in the Final Site Investigation Report (ABB-ES, 1993a). Based on the results of the Site Investigations at these Study Areas, the Army decided to conduct Supplemental Site Investigations at 14 of the original 32 site investigation Study Areas. The findings of the Supplemental Site Investigations are presented in the Supplemental Site Investigation Data Package Groups 2 and 7 (ABB-ES, 1994a). Upon completion of the Supplemental Data Package, it was recommended that three Study Areas (Study Area 41, 43G and 43J) should progress to the Remedial Investigations and Feasibility Study phase. The name designation for each of these Study Areas were administratively changed to Areas of Contamination, and will be addressed as such in future Remedial Investigation Report. This Report presents the finding from Area of Contamination 41.

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EXECUTIVE SUMMARY

ABB Environmental Services, Inc. (ABB-ES) has prepared this Remedial Investigation (RI) Report on Area of Contamination (AOC) 41 at the Fort Devens U.S. Army Installation, Massachusetts (Fort Devens) to support Task Order 005 of Contract DAAA15-91-D-0008 with the U.S. Army Environmental Center (USAEC). This RI Report details the results of the RI and previous investigations completed at AOC 41, which were completed in accordance with relevant U.S. Environmental Protection Agency (USEPA) and USAEC guidance. Fort Devens is currently on the National Priorities List, and AOC 41 is considered as a subsite to the entire installation.

The RI field investigation was conducted at AOC 41 during September and October 1994, and included a surficial geophysical survey, nine test pits, installation of 11 groundwater monitoring wells, subsurface soil and soil gas sampling for field and off-site laboratory analysis, and two rounds of groundwater sampling from the new and the six existing monitoring wells for off-site laboratory analysis. The scope of work for this RI at AOC 41 was specified by the USAEC based on previous studies and investigations, and in consideration of USEPA and Massachusetts Department of Environmental Protection (MADEP) comments on previous investigations and reports. USAEC directed this RI at AOC 41 to characterize the nature and distribution of the contamination in groundwater, and attempt to locate the source of the groundwater contamination. The waste material located at AOC 41 does not pose a significant risk to human health or the environment, but will be included under the landfill consolidation study. Previous data collected from surface water and sediment in New Cranberry Pond indicated that ecological receptors are not being impacted from AOC-derived contaminants.

In general, the efforts associated with this RI have provided a conceptual model which does not precisely locate the source of the groundwater contamination, but does show that the source is within the area investigated during the RI. The results of the RI also indicate that the highest concentrations of the site-related groundwater contamination (up to 200 micrograms per liter of trichloroethene (TCE) are above the USEPA's Maximum Contaminant Levels (MCLs). However, it appears that the contamination within the affected groundwater zone has not

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EXECUTIVE SUMMARY

migrated beyond the existing downgradient monitoring wells. If the site-related contaminants did move further downgradient, they would likely migrate to the north-northeast and eventually discharge into the Nashua River rather than impact the water quality of the South Post potable water supply (Well D-1). Hydrogeologic data from AOC 41 indicated that the groundwater is not discharging to New Cranberry Pond.

The analytical data indicated that the groundwater contamination (consisting predominantly of TCE), 1,1,2,2-tetrachloroethane, and tetrachloroethene appears to be presently located at the water table; and that the water quality of the deeper portion of the downgradient aquifer has not been adversely impacted by past site activities.

A key issue for the AOC 41 RI is the future use of groundwater in the area. AOC 41 is on the western side of the South Post Impact Area (SPIA), an area of Fort Devens which is used mainly for the field training of active duty and reserve troops. The South Post will be retained by the Army and will continue to be used for training activities (BRAC, 1991). Therefore, future land and groundwater uses will remain the same as the current uses.

Investigations at other AOCs on the South Post have been completed and have considered future land and groundwater uses as part of their investigations. In these three Functional Area I RIs (AOC 25, EOD Range; AOC 26, Zulu Ranges 1 and 2; and, AOC 27, Hotel Range), it was determined in the human health risk assessment that, except for the South Post water point (Well D-1), groundwater on the South Post does not represent a current or potential future source of drinking water (Ecology and Environment, Inc. [E&E], 1994). Well D-1 is located 2,500 feet north of AOC 41 on Dixie Road. The well is used as a water supply for troops who train on the South Post. These troops have been estimated by E&E to spend no more than two weeks per year at the South Post. The RI report also indicated that Fort Devens Range Control Staff do not use the water from Well D-1, and that no plans exist to provide connections to the Range Control Offices.

Well D-1 has been sampled four times since 1991 as part of environmental investigations. Only one organic compound, bis(2-ethylhexyl)phthalate, has exceeded MCLs and its presence has been attributed to laboratory or sampling

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contamination. Based on the presumed local and regional groundwater flow, it does not appear that Well D-1 would be impacted by contaminants from AOC 41.

In the Functional Area I RI, it was estimated that exposure to Well D-1 water would be limited to a two-week-per-year exposure period. In response to USEPA comments on the RI, E&E will modify the Functional Area I RI to quantitatively estimate the health risks from short-term consumption of Well D-1 water (for a two-week-per-year exposure period). ABB-ES used these findings to prepare a similar quantitative risk evaluation for this RI report.

The RI for AOC 41 also made the same assumptions about the future use of groundwater as were made by E&E for the other South Post AOCs, assuming that groundwater associated with AOC 41 does not represent a potential future water supply. Therefore, the baseline human health risk assessment was limited to an evaluation of the exposure potential to AOC 41, and a summary of E&Es quantitative risk evaluation for Well D-1.

Other environmental media at AOC 41 were sampled in the previous investigations. A discussion of these media is presented below.

Soil. Surface soil associated with the waste material at AOC will not be addressed in this RI, but will be addressed separately under the Fort Devens Landfill Consolidation Operable Unit feasibility study or the future South Post land use management plan. This RI provides a narrative summary of the findings of the previous soil investigations at the AOC. However, it does not present all of the off-site analytical soil data reported in previous investigations, nor does it estimate health risks associated with soil sampled during the previous investigations.

Surface Water/Sediment. Although surface water and sediment at New Cranberry Pond were sampled during previous investigations, the RI has demonstrated that New Cranberry Pond is not hydrologically connected with AOC 41, and therefore, a discussion of the surface water and sediment results is not included in this RI.

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EXECUTIVE SUMMARY

Recommendation

Based on the results and interpretations of the RI, and the future land and groundwater use, ABB-ES recommends the following actions:

- That no further remedial investigations be performed at AOC 41, that a groundwater monitoring Record of Decision and Proposed Plan be prepared and implemented, and that monitoring should be performed at Well D-1.

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1.0 INTRODUCTION

This Remedial Investigation (RI) Report (Data Item A009) for Area of Contamination (AOC) 41 at the Fort Devens U.S. Army Installation (Fort Devens), in north central Massachusetts was prepared by ABB Environmental Services, Inc. (ABB-ES) as a component of Task Order 005 of Contract DAAA15-91-D-0008 with the U.S. Army Environmental Center¹ (USAEC). This report details the results of the RI program at AOC 41, which was completed in accordance with relevant USAEC and U.S. Environmental Protection Agency (USEPA) guidance.

1.1 PURPOSE AND SCOPE

The scope of work for the RI at AOC 41 was specified by the USAEC based on previous studies and investigations, and USEPA and Massachusetts Department of Environmental Protection (MADEP) comments on prior investigations conducted by ABB-ES at this AOC.

Prior activities included Site Investigation (SI) activities, and Supplemental SI (SSI) activities. Each investigation phase, directed by USAEC, was undertaken to establish the nature and distribution of site-related contaminants in groundwater, surface water, sediment, surface soil, and subsurface soil at AOC 41. These data were collected in order to provide a basis for evaluating and recommending remedial alternatives for potential site remediation, if necessary. The nature of the impacts has been evaluated from individual soil, groundwater, surface water, and sediment samples. The following activities were included in the investigation:

- a terrain conductivity survey and magnetometer survey were conducted in an attempt to locate the source of the site contaminants detected in groundwater;

¹In January 1993, the U.S. Army Toxic Hazardous Materials Agency (USATHAMA) became the U.S. Army Environmental Center (USAEC). Throughout the RI Report, "USATHAMA" will be used in reference to reports and other material that predate this name change.

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SECTION 1

- completion of screened auger borings and the sampling of groundwater for field analysis;
- surface soil sampling for the waste material's cover soils;
- test pitting and subsurface soil sampling at geophysical anomalies to locate site contaminant source area;
- surface water and sediment sampling;
- installation of groundwater monitoring wells and the sampling of groundwater for field and off-site laboratory analyses;
- aquifer testing for hydraulic conductivity determination;
- vertical and horizontal location surveys.

1.2 REPORT ORGANIZATION

Preparation of the RI Report consisted of characterizing the geologic, and hydrogeologic conditions and assessing the distribution, migration, potential receptors, and potential effects of identified chemicals on human receptors. The content and presentation of the report relies heavily upon the figures and tables which present the data in the context of exploration locations on site maps. The text within the report supports the figures, and provides detail, interpretation, and analysis that cannot be presented in figures.

After acquiring and evaluating the field and off-site laboratory data and identifying chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs), ABB-ES has prepared this RI Report for AOC 41 in accordance with USEPA and USAEC guidance. The report describes the field methods employed; presents, summarizes, and evaluates the relevant background information, results, and conclusions from previous investigations; presents the RI field and off-site laboratory data; and assesses the potential human health risks.

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Section 2.0 of this report describes the history and physical setting of Fort Devens. Section 3.0 summarizes the investigation programs, including the field procedures, analytical program, QA and QC, and data management. Section 4.0 presents potential ARARs and background concentrations of inorganic analytes in soil and groundwater. Section 5.0 of this report summarizes the AOC 41 background and physical conditions, previous investigations, technical objectives of the RI, and the RI sampling and investigatory techniques. Section 6.0 presents the geology and hydrogeology for the site. Section 7.0 presents the nature and distribution of detected site contaminants. Section 8.0 outlines the fate and transport of the detected site contaminants. Section 9.0 presents the human health baseline risk assessment, and Section 10.0 presents the summary of the conclusions and recommendations for AOC 41. Figures and tables associated with each section are presented at the end of each section.

In accordance with the FFA, this RI report will be presented in a Draft version, and after regulatory review, a Final version.

1.3 PROJECT OBJECTIVES

Objective of the project at AOC 41 was to perform an RI in accordance with relevant MADEP and USEPA guidance and in compliance with USAEC-approved field methods and procedures. The purpose of the RI conducted at AOC 41 was to further define the site contaminants detected in groundwater during the previous SI and SSI at this AOC, and to determine whether remediation of the site contaminants is warranted.

1.4 PROJECT APPROACH

In order to meet the project objectives, a significant effort was focused on the production of RI planning documents. The planning documents were developed in compliance with the appropriate regulatory guidance for remedial investigations, regulatory and USAEC comments, and results of previous investigations.

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SECTION 1

The project plans were designed to answer data gaps identified from the previous investigations and gather additional data on the physical conditions of the AOC, the nature and distribution of site-related contaminants, and determine the impact on human receptors.

1.4.1 Project Operations Plan

The principal planning document was the ABB-ES Fort Devens Project Operations Plan (POP) (ABB-ES, 1992a, 1993e), which provides detailed descriptions and discussions of the elements essential to conducting field investigation activities. The POP was revised between the 1992 SI and the 1993 SSI field investigations to include new sampling techniques. The purpose of this plan was to define responsibilities and authorities for data quality, and to define requirements for assuring that the field investigation activities undertaken by ABB-ES at Fort Devens were planned and executed in a manner consistent with USAEC quality assurance (QA) program objectives. The POP includes the specified elements of a Sampling and Analysis Plan (SAP) and Health and Safety Plan (HASP). The SAP includes the essential elements of the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan (FSP). USEPA has prepared guidance on the preparation of a POP in "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring"; (OWRS QA-1); (USEPA, 1984). Guidance was designed to eliminate the necessity for preparation of multiple, redundant documents.

Requirements of the POP were applied to ABB-ES and subcontractor activities related to the collection of environmental data at Fort Devens. The POP adheres to the requirements and guidelines contained in the "USAEC QA Program, January 1990" for collection and analysis of samples and the USAEC "Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports, March 1987" for the installation of borings and monitoring wells, and for land survey location. In addition, the POP meets guidelines of USAEC chain-of-custody (COC) procedures.

The ABB-ES Fort Devens POP provides guidance and specifications to ensure that samples are obtained under controlled conditions using appropriate, documented procedures, samples are identified uniquely, and are controlled through sample tracking systems and COC protocols. The POP also includes

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specifications to ensure that field determinations and off-site laboratory analytical results are of known quality and are valid, consistent, and compatible with the USAEC chemical data base through the use of certified methods, preventive maintenance, calibration and analytical protocols, quality control (QC) measurements, review, correction of out-of-control situations, and audits. The POP also specifies the methods and procedures to be used to ensure that calculations and evaluations are accurate, appropriate, and consistent throughout the project; generated data are validated and their use in calculations is documented; and records are retained as documentary evidence of the quality of samples, applied processes, equipment, and results.

The HASP was prepared as an integral element of the POP in accordance with the same schedule and review requirements (ABB-ES, 1992a, 1993e, Appendix A). The HASP complies with EM 385-1-1, AMC-R-385-100, and Fort Devens safety requirements, as well as Occupational Safety and Health Administration (OSHA) Regulations 29 CFR 1910.120. The HASP development was based on appropriate information contained in previous investigation documents from Fort Devens. The HASP portion of the POP ensures that health and safety procedures are maintained by requiring inclusion of the health and safety staff function in the project organization.

1.4.2 Task Order Work Plan

The background, rationale, and specific scope for the RI are set forth in a second companion planning document, the Task Order Work Plan. The Revised Final Task Order Work Plan for AOC 41 was prepared under a modification to Contract DAAA-91-D-0008 Task Order No. 005 (ABB-ES, 1994b). The Revised Final Task Order Work Plan was developed to comply with the Massachusetts Contingency Plan (MCP) (310 Code of Massachusetts Regulations [CMR] 40.000); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the corrective action provisions of the Hazardous and Solid Waste Amendments; and the Toxic Substances Control Act. Work conducted under the Revised Final Task Order Work Plan was performed in accordance with the provisions of the Federal Facility Agreement (FFA) (USEPA and U.S. Army, 1991) and USAEC guidelines.

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Background information provided in the Revised Final Task Order Work Plan for AOC 41 was based largely on information in the Master Environmental Plan (MEP), review of installation documents, observations made during site visits, interviews with installation personnel, and previous investigations conducted by ABB-ES. Summaries of information documented in the MEP for AOC 41 and discussions of specific field activities conducted under this modification to Task Order No. 005 were included in the Revised Final Task Order Work Plan. The discussions focused specifically on the objectives and scope of proposed RI activities.

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2.0 INSTALLATION BACKGROUND AND DESCRIPTION

Fort Devens is located in the towns of Ayer and Shirley (Middlesex County) and Harvard and Lancaster (Worcester County), approximately 35 miles northwest of Boston, Massachusetts. It lies within the Ayer, Shirley, and Clinton map quadrangles (7½-minute series). The installation occupies approximately 9,260 acres and is divided into the North Post, the Main Post, and the South Post (Figure 2-1).

Over 6,000 acres at Fort Devens are used for training and military maneuvers, and over 3,000 acres are developed for housing, buildings, and other facilities; the installation has been reported as the largest undeveloped land holding under a single owner in north-central Massachusetts (United States Fish and Wildlife Service [USFWS], 1992).

The South Post is located south of Massachusetts Route 2 and is largely undeveloped. The Main Post and North Post primarily contain developed lands, including recreational areas (e.g., a golf course and Mirror Lake), training areas, and an airfield. AOC 41 is located near the eastern boundary of the South Post (Figure 2-2).

The following subsections describe the history and physical setting of Fort Devens.

2.1 HISTORY

Camp Devens was created as a temporary cantonment in 1917 for training soldiers from the New England area. It was named after Charles Devens -- a Massachusetts Brevet Major General in the Union Army during the Civil War who later became Attorney General under President Rutherford Hayes. Camp Devens served as a reception center for selectees, as a training facility, and, at the end of World War I, as a demobilization center (Marcoa Publishing Inc., 1990). At Camp Devens, the 1918 outbreak of Spanish influenza infected 14,000 people, killed 800, and caused the installation to be quarantined (McMaster et al., 1982). Peak military strength during World War I was 38,000. After World War II,

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Camp Devens became an installation of the U.S. Army Field Forces, CONARC in 1962 and the U.S. Army Forces Command in 1973 (Biang et al., 1992).

In 1921, Camp Devens was placed in caretaker status. During summers from 1922 to 1931, it was used as a training camp for National Guard troops, Reserve units, Reserve Officer Training Corps (ROTC) cadets, and the Civilian Military Training Corps. In 1929, Dr. Robert Goddard used Fort Devens to test his early liquid-fuel rockets, and there is a monument to him on Sheridan Road near Jackson Gate (Fort Devens Dispatch, 1992).

In 1931, troops were again garrisoned at Camp Devens. It was declared a permanent installation, and in 1932 it was formally dedicated as Fort Devens. During the 1930s, there was a limited building program, and beautification projects were conducted by the Works Progress Administration (WPA) and Civilian Conservation Corps.

In 1940, Fort Devens became a reception center for New England draftees. It expanded to more than 10,000 acres. Approximately 1,200 wooden buildings were constructed, and two 1,200-bed hospitals were built. In 1941, the Army Airfield was constructed by the WPA in a period of 113 days (Fort Devens Dispatch, 1992). In 1942, the Whittemore Service Command Base Shop for motor vehicle repair (Building 3713) was built, and at the time it was known as the largest garage in the world (U.S. Army, 1979). The installation's current wastewater treatment plant was also constructed in 1942 (Biang et al., 1992).

During World War II, more than 614,000 inductees were processed. Fort Devens' population reached a peak of 65,000. Three Army divisions and the Fourth Women's Army Corps trained at Fort Devens, and it was the location of the Army's Chaplain School, the Cook and Baker School, and a basic training center for Army nurses. A prisoner of war camp for 5,000 German and Italian soldiers was operated from 1944 to 1946. At the end of the war, Fort Devens again became a demobilization center, and in 1946 it reverted to caretaker status.

Fort Devens was reactivated in July 1948 and again became a reception center during the Korean Conflict. It has been an active Army facility since that time.

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Currently the mission at Fort Devens is to command and train its assigned duty units; operate the South Boston Support Activity in Boston, Massachusetts, Sudbury Training Annex, and Hingham U.S. Army Reserve (USAR) Annex; and support the 10th Special Forces Group (A), the U.S. Army Intelligence School, Fort Devens, the U.S. Army Reserves, Massachusetts Army National Guard, and Reserve Officer Training Programs. No major industrial operations occur at Fort Devens, although several small-scale industrial operations are performed under the Directorate of Plans, Training, and Security; the Directorate of Logistics; and the Directorate of Engineering and Housing. The major waste-producing operations performed by these groups are photographic processing and maintenance of vehicles, aircraft, and small engines. Past artillery fire, mortar fire, and waste explosive disposal at Fort Devens are potential sources for explosives contamination (USAEC, 1993).

In 1985, Fort Devens applied for a Resource Conservation and Recovery Act (RCRA) Part B Permit for its hazardous waste storage facility. The submission included a list of Solid Waste Management Units (SWMUs) that showed potential for the release of hazardous materials to the environment. Under the FFA between the Army and the USEPA (USEPA and U.S. Army, 1991), these potential areas of contamination are referred to as Study Areas (SAs). In cooperation with the MADEP, USEPA Region I issued a draft permit and selected ten SAs for corrective action. In 1986, a final permit was issued along with a list of 40 SAs. At the request of Fort Devens, six additional SAs were added to the list, for a total of 46 SAs.

Argonne National Laboratory's (ANL) Environmental Assessment and Information Sciences Division conducted an environmental assessment of the 46 SAs in November 1988, as part of the environmental restoration of Fort Devens. The objective of the ANL assessment was to characterize on-site contamination and provide recommendations for potential response actions. In 1989, Fort Devens was placed on the National Priority List. During a subsequent site visit by ANL in 1990, eight more SAs were added, bringing the total to 54. Since that time, four more areas of potential contamination have been identified, for a current total of 58 SAs.

Results of ANL's assessment are reported in a document entitled the Master Environmental Plan for Fort Devens, Massachusetts (Biang et al., 1992). The

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MEP summarizes preliminary assessment activities conducted by ANL and provides an historical summary of the installation, discusses the geologic and hydrologic setting, discusses the nature and distribution of contamination, and proposes response actions for each of the 58 SAs. The MEP provided the basis for much of the planning effort for the 1992 investigation of AOC 41, then known as SA 41. Based on results of the 1992 SI, additional investigation was conducted under the SSI in 1993. Results of the 1993 SSI indicated an RI was required to fully characterize the site. The RI field investigation was conducted during the Fall and Winter of 1994/1995.

Under Public Law 101-510, the Base Realignment and Closure Act (BRAC) 1990, Fort Devens has been identified for closure by July 1997, and 4,600 acres are to be retained to establish a Reserve Component enclave and regional training center.

2.2 PHYSICAL SETTING

The climate, vegetation, ecology, physiography, soils, surficial and bedrock geology, and regional hydrogeology of Fort Devens are described in the subsections that follow.

2.2.1 Climate

The climate of Fort Devens is typical of the northeastern United States, with long cold winters and short hot summers. Climatological data were reported for Fort Devens by U.S. Department of the Army (1979), based in part on a 16-year record from Moore Army Airfield (MAAF).

Mean daily minimum temperature in the coldest months (January and February) is 17 degrees Fahrenheit (°F), and the mean daily maximum temperature in the hottest month (July) is 83°F. The average annual temperature is 58°F. There are normally 12 days per year when the temperature reaches or exceeds 90°F and 134 days when it falls to or below freezing.

The average annual rainfall is 39 inches. Mean monthly precipitation varies from a low of 2.3 inches (in June) to a high of 5.5 inches (in September). The average

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annual snowfall is 65 inches, and snowfall has been recorded in the months of September through May (falling most heavily from December through March).

Wind speed averages 5 miles per hour (mph), ranging from the highest monthly average of 7 mph (March-April) to the lowest monthly average of 4 mph (September).

Average daytime relative humidities range from 71 percent (January) to 91 percent (August), and average nighttime relative humidities range from 46 percent (April) to 60 percent (January).

2.2.2 Vegetation

The Main and North Posts at Fort Devens are primarily characterized by urban and developed cover types. Approximately 56 percent of that area is covered by developed lands, the golf course, the airfield, and the wastewater infiltration beds. Early successional forest cover types (primarily black cherry-aspen hardwoods) cover approximately 2 percent of the area, mixed oak-red maple hardwoods approximately 20 percent, and white pine-hardwood mixes approximately 11 percent. The rest of the North and Main Posts are characterized by various coniferous species, shrub habitat, and herbaceous cover types.

Much of the South Post is undeveloped forested land. The area includes approximately 8 percent early successional forest (black cherry, red birch, grey birch, quaking aspen, red maple); 26 percent mixed oak hardwoods; and 9 percent coniferous forest (white pine, pitch pine, red pine). Four percent of the area is covered by a mixed shrub community. The 200-acre Turner Drop Zone is maintained as a grassland that represents a "prairie" habitat. Vegetative cover in the large "impact area" of the central South Post has not been mapped in detail. It is dominated by fire-tolerant species such as pitch pine and scrub oak.

Extensive sandy glaciofluvial soils are found in the Nashua River Valley, particularly in the South and North Post areas of Fort Devens. Extensive accumulations of these soils are unusual in Massachusetts outside of Cape Cod and adjacent areas of southeastern Massachusetts, and they account for some of the floral and faunal diversity at the installation.

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2.2.3 Ecology

Fort Devens encompasses numerous terrestrial, wetland, and aquatic habitats in various successional stages. Floral and faunal diversity is strengthened by the installation's close proximity to the Nashua River; the amount, distribution, and nature of wetlands; and the undeveloped state and size of the South Post (USFWS, 1992). Much of Fort Devens was formerly agricultural land and included pastures, woodlots, orchards, and cropped fields. Existing habitat types reflect this agrarian history, ranging from abandoned agricultural land to secondary growth forested regions. Fort Devens is generally reverting back to a forested state.

There are 1,313 acres of wetlands at Fort Devens. Wetlands are primarily palustrine, although riverine and lacustrine types are also found. Forested palustrine floodplain wetlands associated with the Nashua River and its tributary Nonacoicus Brook are located on Fort Devens' Main and North Posts. These include 191 acres of flooded areas, emergent marsh, and shrub wetlands. Also present are 245 acres of isolated regions of palustrine wetlands and lacustrine systems. On the South Post, there are 877 acres of wetlands, consisting of deciduous forested wetlands, deciduous shrub swamps, emergent marsh, open lacustrine waters in ponds, and open riverine waters.

Approximately half of Fort Devens' land area abuts the northern boundary of the Oxbow National Wildlife Refuge (NWR), a federal resource administered as part of the Great Meadows NWR (USFWS, 1992).

Fort Devens supports an abundance and diversity of wildlife. Identified taxa include 771 vascular plant species, 538 species of butterflies and moths, eight tiger beetle species, 30 vernal pool invertebrates, 15 amphibian species (six salamanders, two toads, seven frogs), 19 reptile species (seven turtles, 12 snakes), 152 bird species, and 42 mammal species. Status of fish populations in Fort Devens aquatic systems has not been fully defined.

Rare and endangered species at Fort Devens include federally listed (endangered) bald eagle and peregrine falcon (both occasional transients); state-listed (endangered) upland sandpiper, ovoid spike rush, and Houghton's flatsedge; state-listed (threatened) Blanding's turtle, cattail sedge, pied-billed grebe, and northern

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harrier; and state-listed (special concern) blue-spotted salamander, grasshopper sparrow, spotted turtle, wood turtle, water shrew, blackpoll warbler, American bittern, Cooper's hawk, sharp-shinned hawk, and Mystic Valley amphipod. Also state-listed as rare or endangered are three Lepidoptera (butterfly and moth) species identified at Fort Devens.

The Massachusetts Natural Heritage Program has developed Watch Lists of unprotected species that are uncommon or rare in Massachusetts. From the Watch Lists, 14 plant species, two amphibian species, and 15 bird species have been observed at Fort Devens.

2.2.4 Physiography

Fort Devens is in a transitional area between the coastal lowland and central upland regions of Massachusetts. All of the landforms are products of glacial erosion and deposition on a crystalline bedrock terrain. Glacial erosion was superimposed on ancient bedrock landforms that were developed by the erosional action of preglacial streams. Generally, bedrock hills and ridges before the onset of Pleistocene glaciation were only moderately modified by glacial action, and remain bedrock hills and ridges today. Similarly, preglacial bedrock valleys remain bedrock valleys. In post-glacial time, streams locally modified the surficial glacial landforms but generally have not affected bedrock.

The predominant physiographic (and hydrologic) feature in the Fort Devens area is the Nashua River (see Figure 2-1). It forms the eastern installation boundary on the South Post, where its valley varies from a relatively narrow channel (at Still River Gate east of AOC 41), to an extensive floodplain with a meandering river course and numerous cutoff meanders (at Oxbow NWR). The Nashua River forms the western boundary of much of the Main Post, and its valley is deep and comparatively steep-sided with extensive bedrock outcroppings on the eastern bank. The river flows through the North Post in a well defined channel within a broad forested floodplain.

Terrain at Fort Devens falls generally into three types. Least common is bedrock terrain, where rocks resistant to both glacial and fluvial erosion remain as topographic highs, sometimes thinly veneered by glacial deposits. Shepley's Hill on the Main Post is the most prominent example.

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A similar but more common terrain at Fort Devens consists of materials (tills) deposited directly by glaciers as they advanced through the area or as ice masses wasted (melted). These landforms often conform to the shape of underlying bedrock surface. They range from areas of comparatively low topographic relief (such as near Lake George Street on the Main Post) to elongated hills (drumlins) whose orientations reflect the direction of glacier movement (such as Whittemore Hill on the South Post).

The third type of terrain was formed by sediment accumulations in glacial-meltwater streams and lakes (glaciofluvial and glaciolacustrine deposits). AOC 41 is located in this type of terrain. This is the most common terrain at Fort Devens, comprising most of the North and South Posts and much of the Main Post. Its form bears little or no relationship to the shape of the underlying bedrock surface. Landforms include extensive flat uplands such as the hills on which the MAAF and the wastewater infiltration beds are located on the North Post. Those are large remnants of what was once a continuous surface that was later incised and divided by downcutting of the Nashua River. Another prominent glacial meltwater feature is the area around Cranberry Pond and H-Range on the South Post. This is classic kame-and-kettle topography formed by sand and gravel deposition against and over large isolated ice blocks, followed by melting of the ice and collapse of the sediments. The consistent elevations of the tops of these ice-contact deposits are an indication of the glacial-lake stage with which they are associated. Mirror Lake and Little Mirror Lake on the Main Post occupy another conspicuous kettle.

2.2.5 Soils

Fort Devens lies within Worcester County and Middlesex County in Massachusetts (see Figure 2-1). Soils of Worcester County have been mapped by the Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA) (SCS, 1985). Mapping of the soils of Middlesex County has not been completed. However, an interim report (SCS, 1991), field sheet #19 (SCS, 1989), and an unpublished general soil map (SCS, undated) are available.

Soil mapping units ("soil series") that occur together in intricate characteristic patterns in given geographic areas are grouped into soil "associations." Soils in the Worcester County portions of Fort Devens consist generally of three

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associations. Three associations also have been mapped in the Middlesex County portions of Fort Devens. Although the mapped associations are not entirely the same on both sides of the county line, the differences reflect differences in definition and the interim status of Middlesex County mapping. General distributions of the soil associations are shown in Figure 2-3, and descriptions of soil series in those associations are provided below.

WORCESTER COUNTY (SCS, 1985)

Winooski-Limerick-Saco Association: The soils at AOC 41 are classified as these types of soil (see Figure 2-3).

Winooski Series. Very deep; moderately well-drained; slopes zero to 3 percent; occurs on floodplains; forms in silty alluvium.

Limerick Series. Very deep; poorly drained; slopes zero to 3 percent; occurs on floodplains; forms in silty alluvium.

Saco Series. Very deep; very poorly drained; slopes zero to 3 percent; occurs on floodplains; derived mainly from schist and gneiss.

Hinckley-Merrimac-Windsor Association:

Hinckley Series. Very deep; excessively drained; slopes zero to 35 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Merrimac Series. Very deep; excessively drained; slopes zero to 25 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Windsor Series. Very deep; moderately well-drained; slopes zero to 3 percent; occurs on floodplains.

Paxton-Woodbridge-Canton Association:

Paxton Series. Very deep; well-drained; slopes 3 to 35 percent; occurs on glacial till uplands; formed in friable till overlying firm till.

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Woodbridge Series. Very deep; moderately well-drained; slopes zero to 15 percent; occurs on glacial till uplands; formed in firm till.

Canton Series. Very deep; well-drained; slopes 3 to 35 percent; occurs on glaciated uplands; formed in friable till derived mainly from gneiss and schist.

MIDDLESEX COUNTY (SCS, 1991)

Hinckley-Freetown-Windsor Association. (This is a continuation of the Hinckley-Merrimac-Windsor Association mapped in Worcester County):

Hinckley Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash terraces, kames, and eskers; formed in gravelly and cobbly coarse textured glacial outwash.

Freetown Series. Deep; very poorly drained; nearly level, organic; occurs in depressions and on flat areas of uplands and glacial outwash plains.

Windsor Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, deltas, and escarpments; formed in sandy glacial outwash.

Quonset-Carver Association:

Quonset Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, eskers, and kames; formed in water-sorted sands derived principally from dark phyllite, shale, or slate.

Carver Series. Deep; excessively drained; nearly level to steep; occurs on glacial outwash plains, terraces, and deltas; formed in coarse, sandy, water-sorted material.

Winooski-Limerick-Saco Association. (This is a continuation of the same association mapped along the Nashua River floodplain in Worcester County).

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2.2.6 Surficial Geology

Fort Devens lies in three topographic quadrangles: Ayer, Clinton, and Shirley. Surficial geology of Fort Devens has been mapped only in the Ayer quadrangle (Jahns, 1953) and Clinton quadrangle (Koteff, 1966); the Shirley quadrangle is unmapped.

Unconsolidated surficial deposits of glacial and postglacial origin comprise nearly all exposed geologic materials at Fort Devens. The glacial units consist of till, deltaic deposits of glacial Lake Nashua, and deposits of glacial meltwater streams.

The till ranges from unstratified gravel to silt, and it is characteristically bouldery. Jahns (1953) and Koteff (1966) recognize a deeper unit of dense, subglacial till, and an upper, looser material that is probably a slightly younger till of englacial or supraglacial origin. Till is exposed in ground-moraine areas of the Main Post (such as in the area of Lake George Street) and on the South Post at and south of Whittemore Hill. It also underlies some of the water-laid deposits (Jahns, 1953). Till averages approximately 10 feet in thickness, but reaches 60 feet in drumlin areas (Koteff, 1966).

Most surficial glacial units in the Nashua Valley are associated with deposition in glacial Lake Nashua, which formed against the terminus of the Wisconsin ice sheet as it retreated northward along the valley. Successively lower outlets were uncovered by the retreating glacier, and the lake level was correspondingly lowered. Koteff (1966) and Jahns (1953) recognize six lake levels (stages) in the Fort Devens area, distinguished generally by elevations and distribution of their associated deposits. The stages are, in order of development: Clinton Stage; Pin Hill Stage; Old Mill Stage; Harvard Stage; Ayer Stage; and Groton Stage.

Glacial lake deposits consist chiefly of sand and gravelly sand. Coarser materials are found in topset beds of deltas built out into the lakes and in glacial stream beds graded to the lakes. Delta foreset beds are typically composed of medium to fine sand, silt, and clay. Lake-bottom deposits, which consist of fine sand, silt, and clay, are mostly covered by delta deposits and are seldom observed in glacial Lake Nashua deposits. One of the few known exposures of glacial lake-bottom sediments in the region is on the South Post near A- and C-Ranges. Here, a section of more than 14 feet of laminated clay was mined for brick-making in the

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early part of this century (Alden, 1925, pp. 70-71). Another area of significant lake-bottom sediments is present at AOC 41 in the South Post. Over 25 feet of sediment is present at this site and the remnants of a brick kiln are near the sediments. The general physical characteristics of glacial lake deposits are the similar regardless of the particular lake stage in which deposits accumulated (Koteff, 1966; Jahns, 1953). Although glaciofluvial and glaciolacustrine sediments are typically well stratified, correlations between borings are difficult because of large distance between explorations.

Postglacial deposits consist mostly of river-terrace sands and gravels; fine alluvial sands and silts beneath modern floodplains; and muck, peat, silt, and sand in swampy areas.

Jahns (1953) also observed a widespread veneer of windblown sand and ventifacts above the glacial materials (and probably derived from them in the brief interval between lake drainage and the establishment of vegetative cover).

2.2.7 Bedrock Geology

Fort Devens is underlain by low-grade metasedimentary rocks, gneisses, and granites. The rocks range in age from Late Ordovician to Early Devonian (approximately 450 million to 370 million years old). The installation is situated approximately 2 miles west of the Clinton-Newbury-Bloody Bluff fault zone, which developed when the ancestral European continental plate collided with and underthrust the ancestral North American plate. The continents resealed in the Mesozoic to form the modern Atlantic Ocean. Fort Devens is located on the very eastern edge of the ancestral North American continental plate. A piece of the ancestral European continent (areas now east of the Bloody Bluff fault) broke off and remained attached to North America.

Preliminary bedrock maps (at scale 2,000 feet per inch) are available for the Clinton quadrangle (Peck, 1975 and 1976) and Shirley quadrangle (Russell and Allmendinger, 1975; Robinson, 1978). Bedrock information for the Ayer quadrangle is from the Massachusetts state bedrock map (at a regional scale of 4 miles per inch) (Zen, 1983) and associated references (Robinson and Goldsmith, 1991; Wones and Goldsmith, 1991). Among these sources, there is

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some disagreement about unit names and stratigraphic sequence; however, there is general agreement about the distribution of rock types.

In contrast to the high metamorphic grade and highly sheared rocks of the Clinton-Newbury zone, the rocks in the Fort Devens area are low-grade metamorphics (generally below the biotite isograd) and typically exhibit less brittle deformation. Major faults have been mapped, however, including the Wekepeke fault exposed west of Fort Devens (in an outcrop 0.25 mile west of the old Howard Johnson rest stop on Route 2).

Figure 2-4 is a generalized summary of the bedrock geology of Fort Devens. It is compiled from Peck (1975), Robinson (1978), Russell and Allmendinger (1975), and Zen (1983), and it adopts the nomenclature of Zen (1983). Because of limited bedrock exposures, the locations of mapped contacts are considered approximate, and the mapped faults are inferred. Rock units strike generally northward to northeastward but vary locally. The bedrock units underlying Fort Devens are as follows:

DSw WORCESTER FORMATION (Lower Devonian and Silurian)

Carbonaceous slate and phyllite, with minor metagraywacke to the west (Zen, 1983; Peck, 1975). Bedding is typically obscure due to a lack of compositional differences. It is relatively resistant to erosion and forms locally prominent outcrops. The abandoned Shaker slate quarry on the South Post is in rocks of the Worcester Formation. The unit corresponds to the "DSgs" and "DSs" units of Peck (1975) and the "e3" unit of Russell and Allmendinger (1975).

So OAKDALE FORMATION (Silurian) Metasiltstone and phyllite. The bedrock was not encountered at AOC 41, however, the bedrock under AOC 41 has been estimated to be part of this formation. It is fine-grained and consists of quartz and minor feldspar and ankerite, and it is commonly deformed by kink banding (Zen, 1983; Peck, 1975; Russell and Allmendinger, 1975). In outcrop it has alternating layers of brown siltstone and greenish phyllite. The Oakdale Formation crops out most visibly on Route 2 just east of the Jackson Gate exit. It corresponds to the "DSsp" unit of Peck (1975), the "e2" unit of Russell and Allmendinger (1975), and "ms" unit of Robinson (1978).

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- Sb BERWICK FORMATION** (Silurian) Thin- to thick-bedded metamorphosed calcareous metasiltstone, biotitic metasiltstone, and fine-grained metasandstone, interbedded with quartz-muscovite-garnet schist and feldspathic quartzite (Zen, 1983; Robinson and Goldsmith, 1991). In areas northwest of Fort Devens, cataclastic zones have been observed (Robinson, 1978).
- Dcgr CHELMSFORD GRANITE** (Lower Devonian) Light-colored and gneissic, even and medium grained, quartz-microcline-plagioclase-muscovite-biotite, pervasive ductile deformation visible in elongate quartz grains aligned parallel to mica. It intrudes the Berwick Formation and Ayer granite (Wones and Goldsmith, 1991).

AYER GRANITE

- Sacgr Clinton facies** (Lower Silurian) Coarse-grained, porphyritic, foliated biotite granite with a nonporphyritic border phase; it intrudes the Oakdale and Berwick Formations and possibly the Devens-Long Pond Facies (Zen, 1983; Wones and Goldsmith, 1991).

- SOad Devens-Long Pond facies** (Upper Ordovician and Lower Silurian) Gneissic, equigranular to porphyroblastic biotite granite and granodiorite. Its contact relationship with the Clinton facies is unknown (Wones and Goldsmith, 1991). Observations of mapped exposures of this unit on Fort Devens indicate that it may not be intrusive.

Bedrock is typically unweathered to only slightly weathered at Fort Devens. Glaciers stripped away virtually all of the preglacially weathered materials, and there has been insufficient time for chemical weathering of rocks in the comparatively brief geologic interval since glacial retreat.

2.2.8 Regional Hydrogeology

Fort Devens is in the Nashua River drainage basin, and the Nashua River is the eventual discharge locus for all surface water and groundwater flow at the installation.

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The water of the Nashua River has been assigned to Class B under Commonwealth of Massachusetts regulations. Class B surface water is "designated for the uses of protection and propagation of fish, other aquatic life and wildlife, and for primary and secondary contact recreation" (314 CMR 4.03).

The principal tributaries of the north-flowing Nashua River at Fort Devens are Nonacoicus Brook and Walker Brook on the North Post; Cold Spring Brook (which is a tributary of Nonacoicus Brook) on the Main Post; and Spectacle Brook and Ponakin Brook (tributaries of the North Nashua River), Slate Rock Brook, and New Cranberry Pond Brook on the South Post (see Figure 2-2).

There are two ponds on Fort Devens' South Post that are called Cranberry Pond. For the purpose of the SI, the isolated kettle pond located east of H-Range is referred to as Cranberry Pond, and the pond impounded in the 1970s on the southern side of AOC 41 is referred to as New Cranberry Pond.

Glacial meltwater deposits constitute the primary aquifer at Fort Devens. In aquifer tests performed as part of the investigations on-post, measured hydraulic conductivities in meltwater deposits were comparatively high-- typically 10^{-3} to 10^{-2} centimeters per second (cm/sec). In till and in clayey lake-bottom sediments, measured hydraulic conductivities were lower and ranged generally from 10^{-6} to 10^{-4} cm/sec. Groundwater also occurs in the underlying bedrock; however, flow is limited because the rocks have no primary porosity and water moves only in fractures and dissolution voids.

Groundwater in the surficial aquifer at Fort Devens has been assigned to Class I under Commonwealth of Massachusetts regulations. Class I consists of groundwaters that are "found in the saturated zone of unconsolidated deposits or consolidated rock and bedrock and are designated as a source of potable water supply" (314 CMR 6.03).

The transmissivity of an aquifer is the product of its hydraulic conductivity and saturated thickness, and as such it is a good measure of groundwater availability. Figure 2-5 shows aquifer transmissivities at Fort Devens, based on the regional work of Brackley and Hansen (1977). Transmissivities in the meltwater deposits range from 10 square feet per day (ft^2/day) to more than 4,000 ft^2/day . Aquifer transmissivities between 10 and 1,350 ft^2/day correspond to potential well yields

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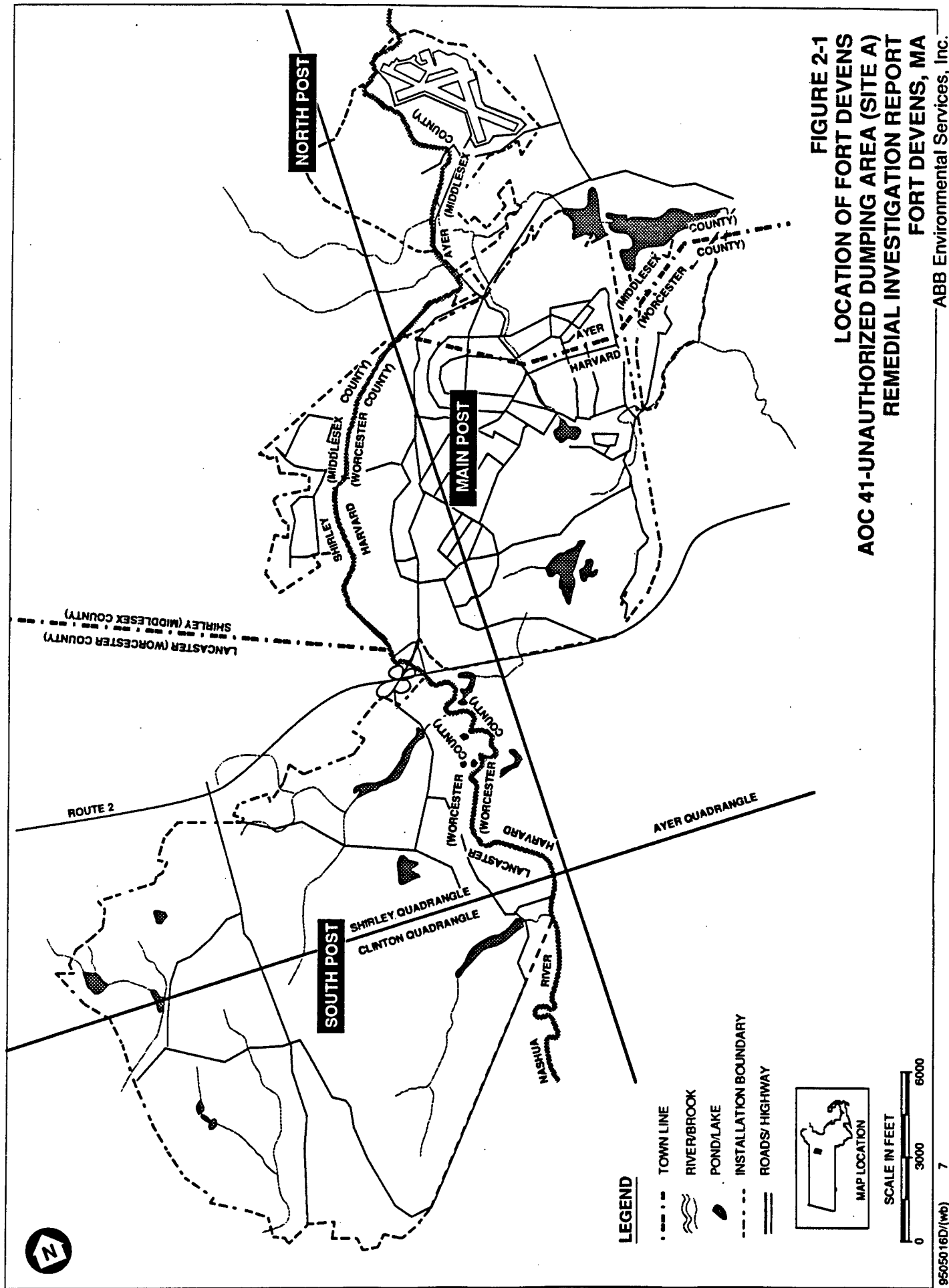
generally between 10 and 100 gallons per minute (gpm); transmissivities from 1,350 to 4,000 ft²/day typically yield from 100 to 300 gpm; and where transmissivities exceed 4,000 ft²/day, well yields greater than 300 gpm can be expected. (Most domestic wells in the area are drilled 100 to 200 feet into bedrock and yield less than 10 gpm. Higher yields are associated with deeper bedrock wells.)

In Figure 2-5, the zones of highest transmissivity are found in areas of thick glacial meltwater deposits on the North and Main Posts, and these encompass the Sheboken, Patton, and McPherson production wells and the largely inactive Grove Pond well-field. The zones of lowest transmissivity are associated with exposed till and bedrock and are located on the Main Post surrounding Shepley's Hill and between Jackson Gate and the parade ground, and on the South Post at Whittemore Hill and isolated areas to the north and west.

A regional study of water resources in the Nashua River basin was reported by Brackley and Hansen (1977). A digital model of overburden and bedrock groundwater flow at Fort Devens is available in a draft final report by Engineering Technologies Associates, Inc. (ETA) (1992) (Figures 2-6 and 2-7).

According to ETA, in the absence of pumping or other disturbances, groundwater recharge occurs in upland areas (e.g., the high ground on the Main Post between Queenstown, Givry, and Lake George Streets, and on the South Post the area around Whittemore Hill). The groundwater flows generally from the topographic highs to topographic lows. It discharges in wetlands, ponds, streams, and directly into the Nashua River. Groundwater discharge maintains the dry-weather flow of the rivers and streams. However, the groundwater flow model does indicate that surface water from New Cranberry Pond is recharging groundwater and flowing north-northeast in the vicinity of AOC 41.

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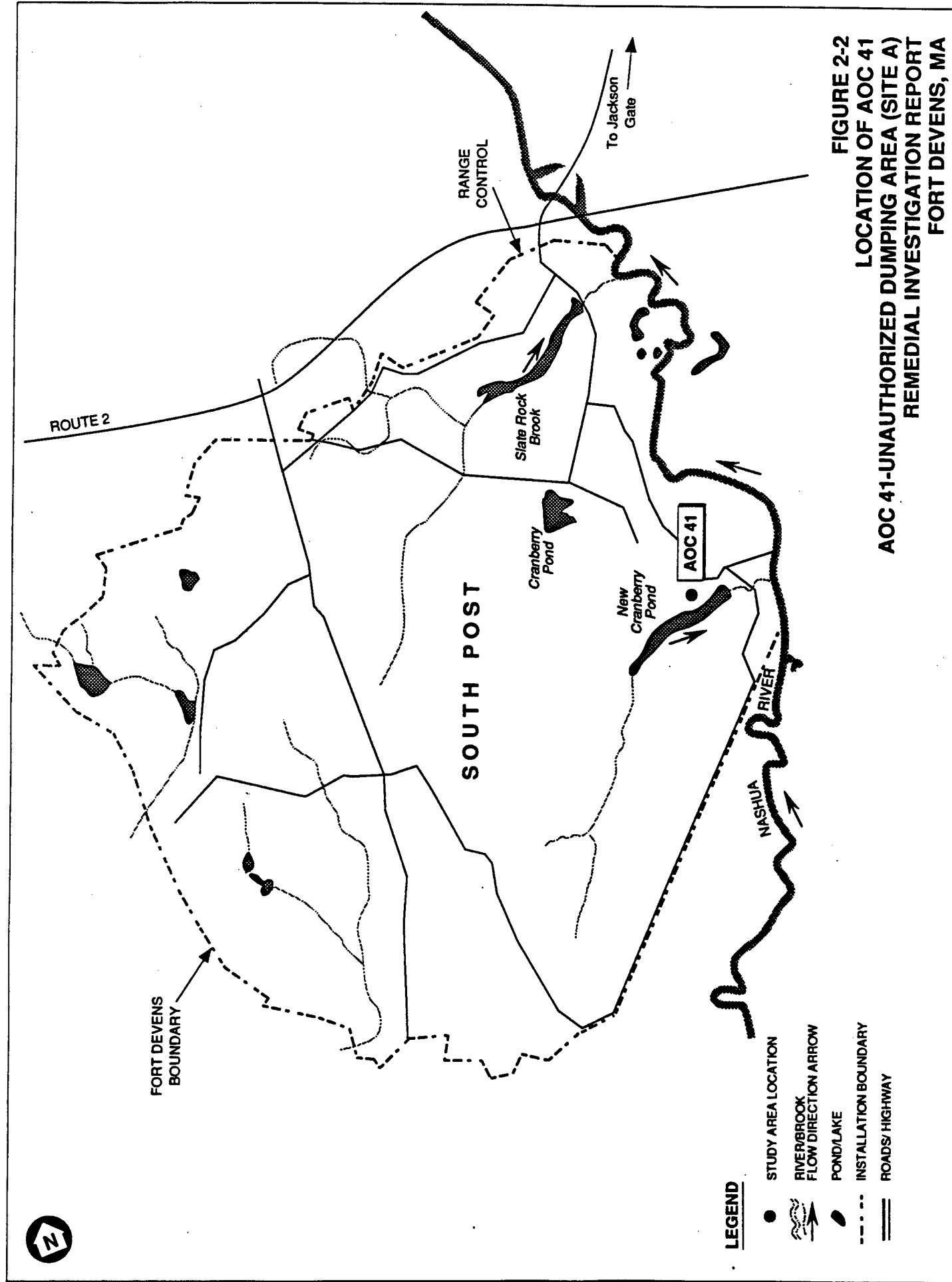


FIGURE 2-2
LOCATION OF AOC 41
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

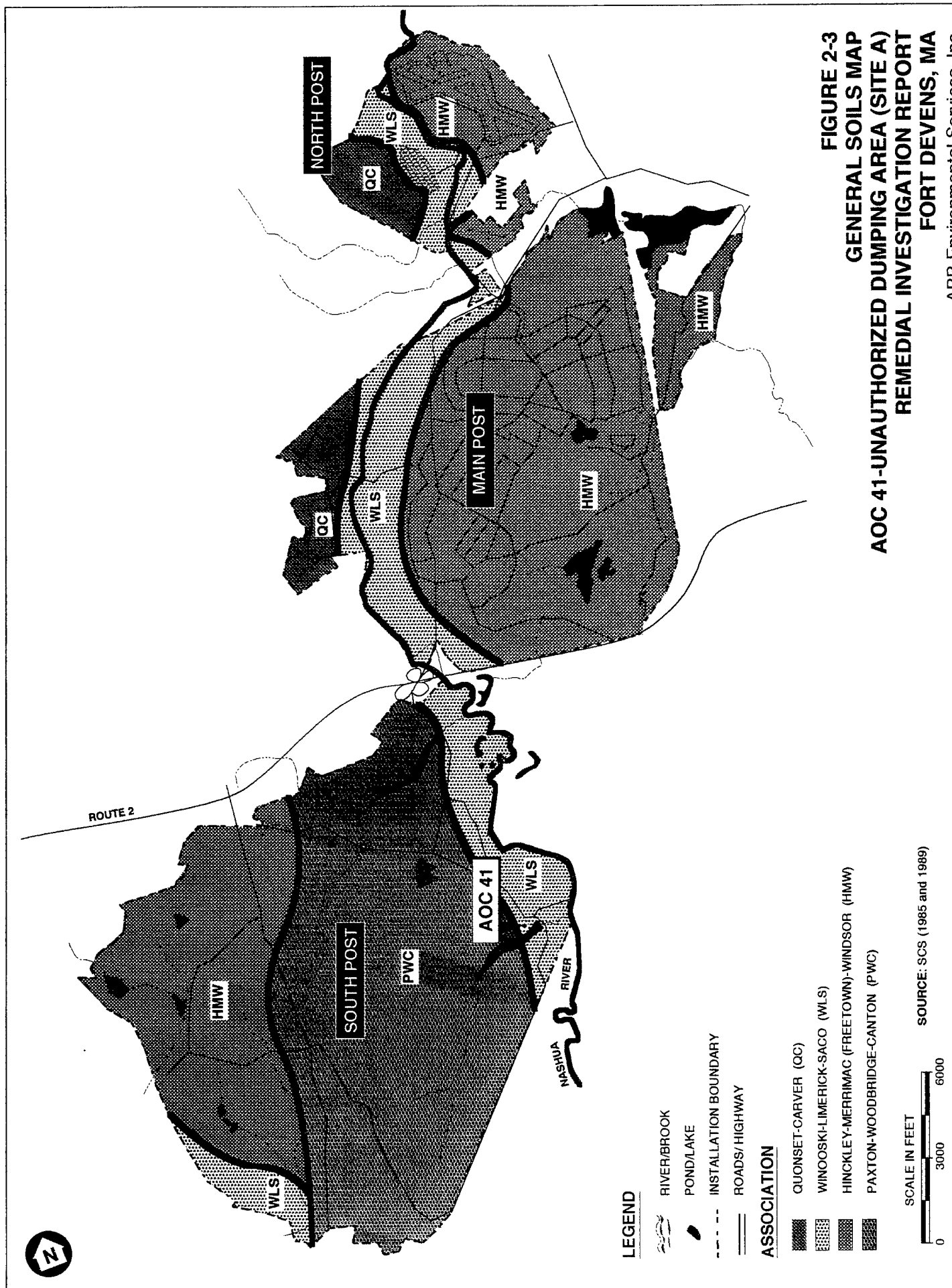


FIGURE 2-3
GENERAL SOILS MAP
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIATION INVESTIGATION REPORT
FORT DEVENS, MA
 ABB Environmental Services, Inc.

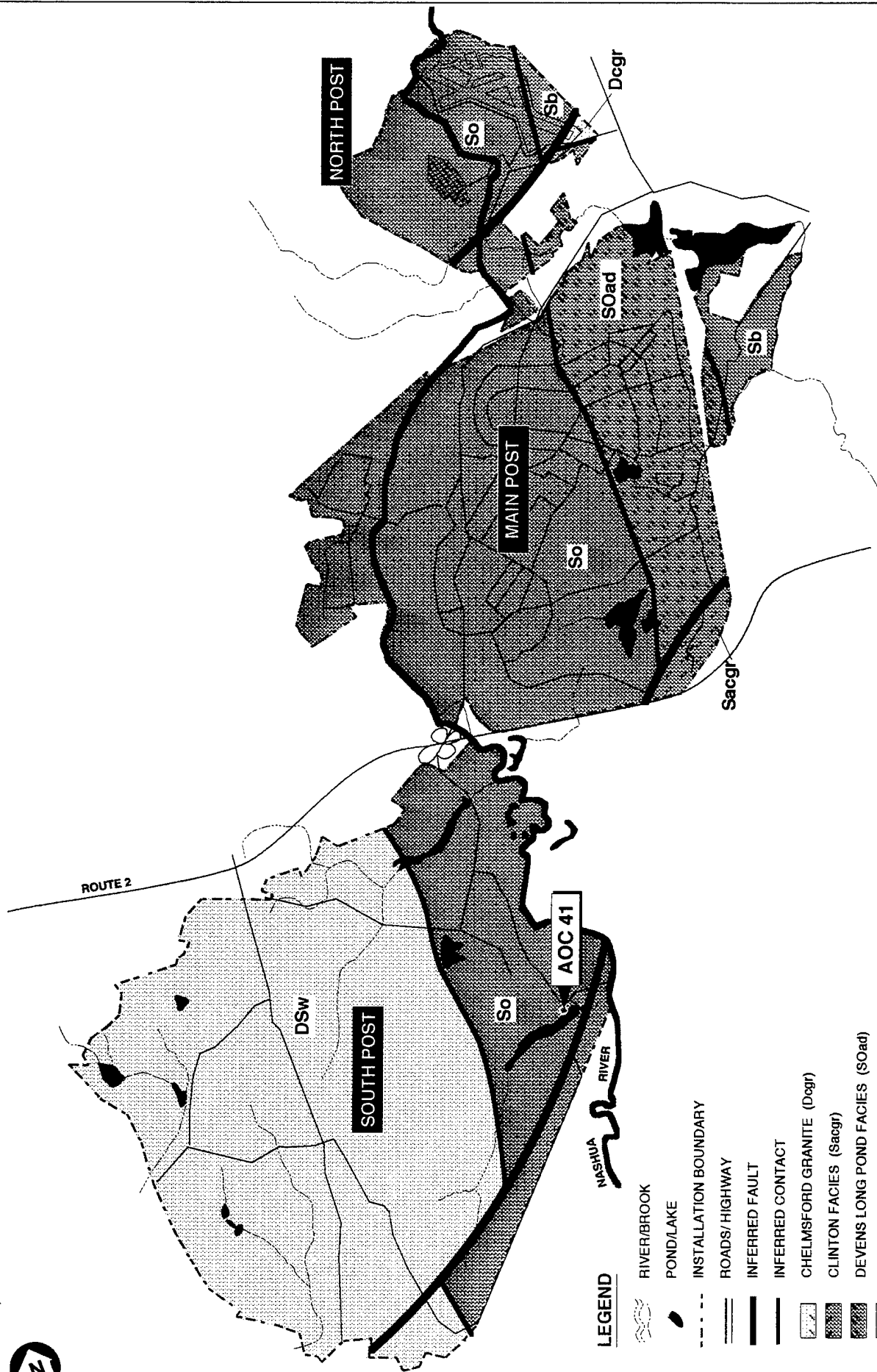
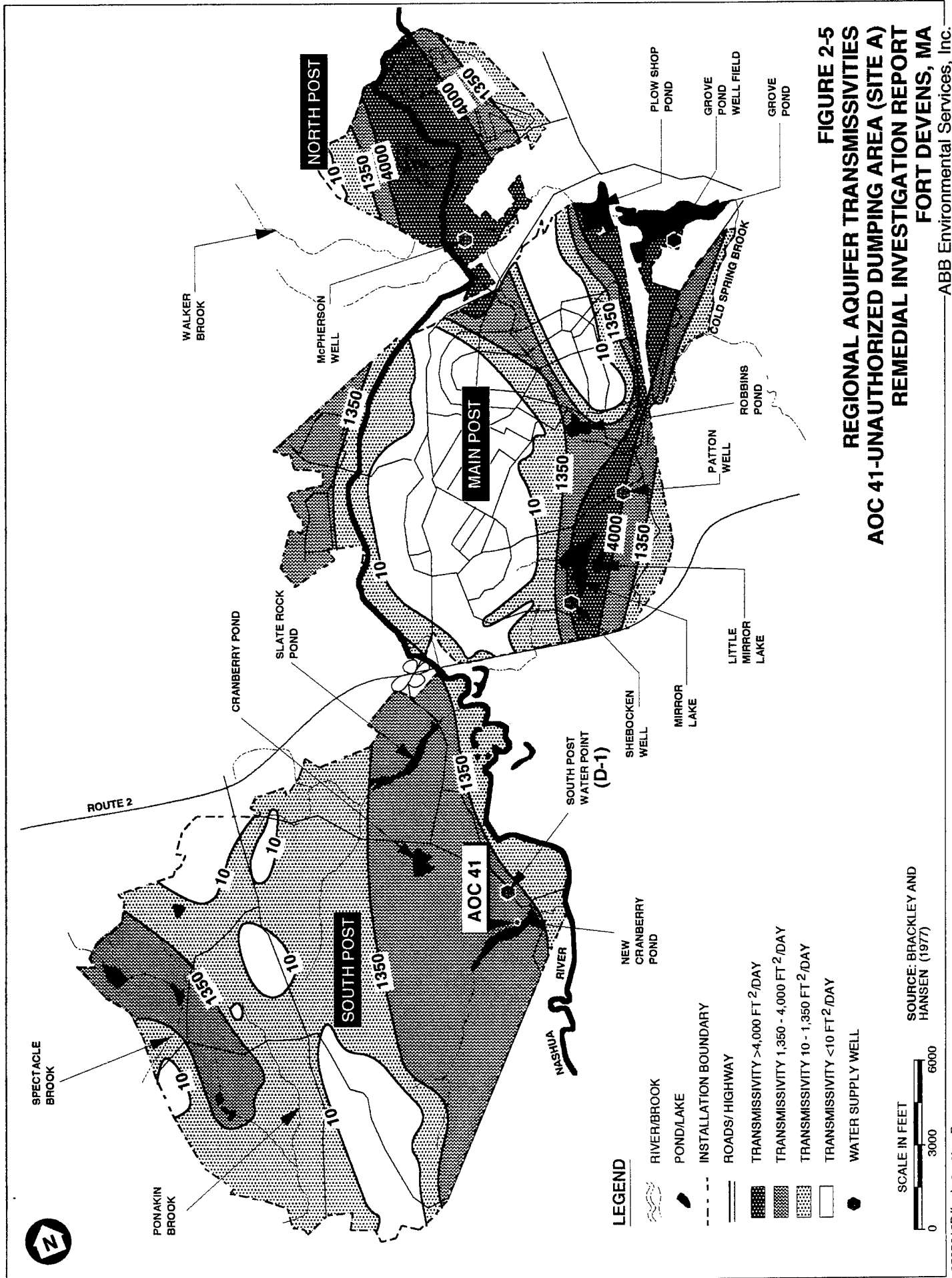
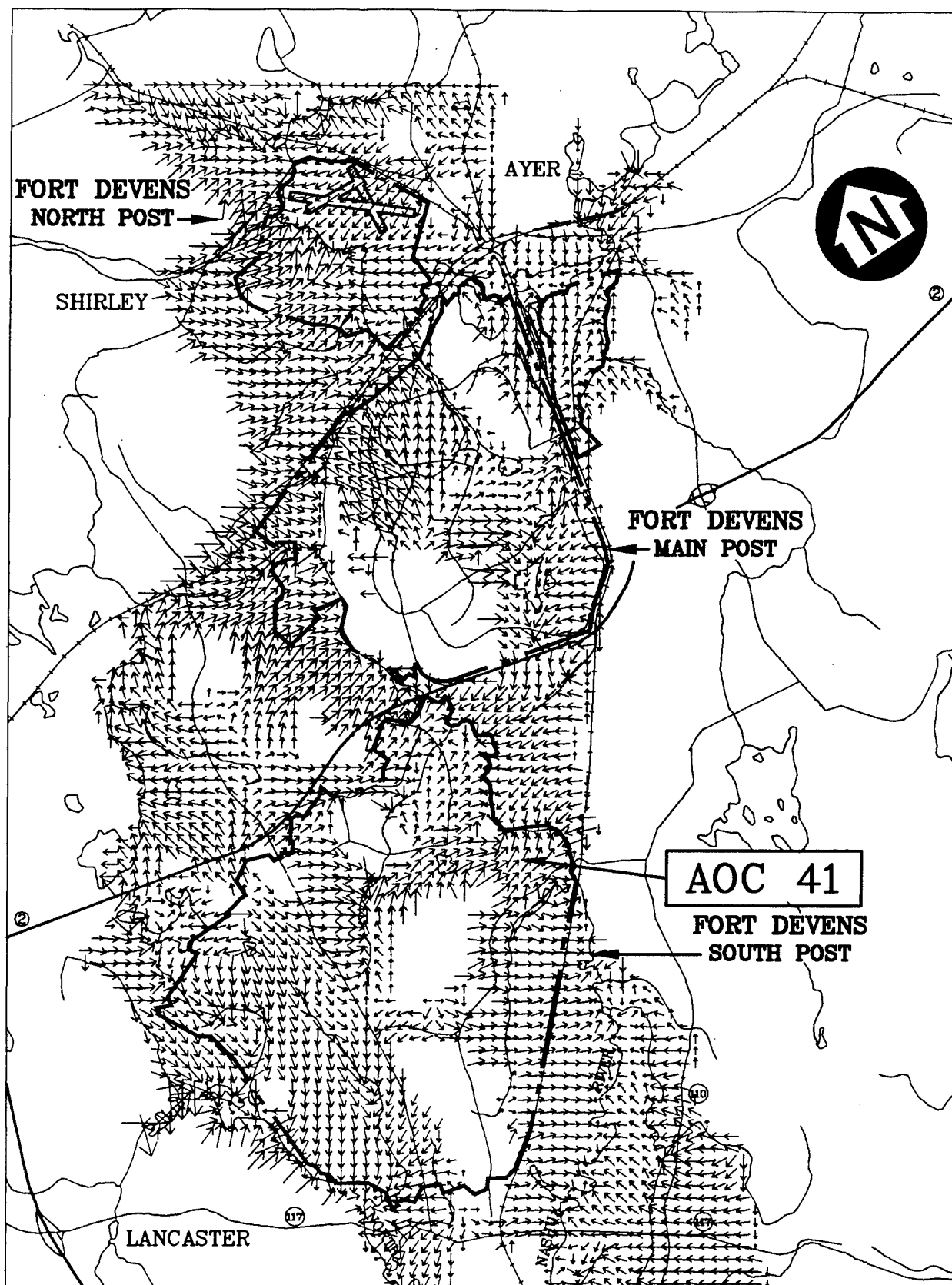


FIGURE 2-4
BEDROCK GEOLOGY
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.





SOURCE:
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA,
ETA, INC. OCTOBER 30, 1992.

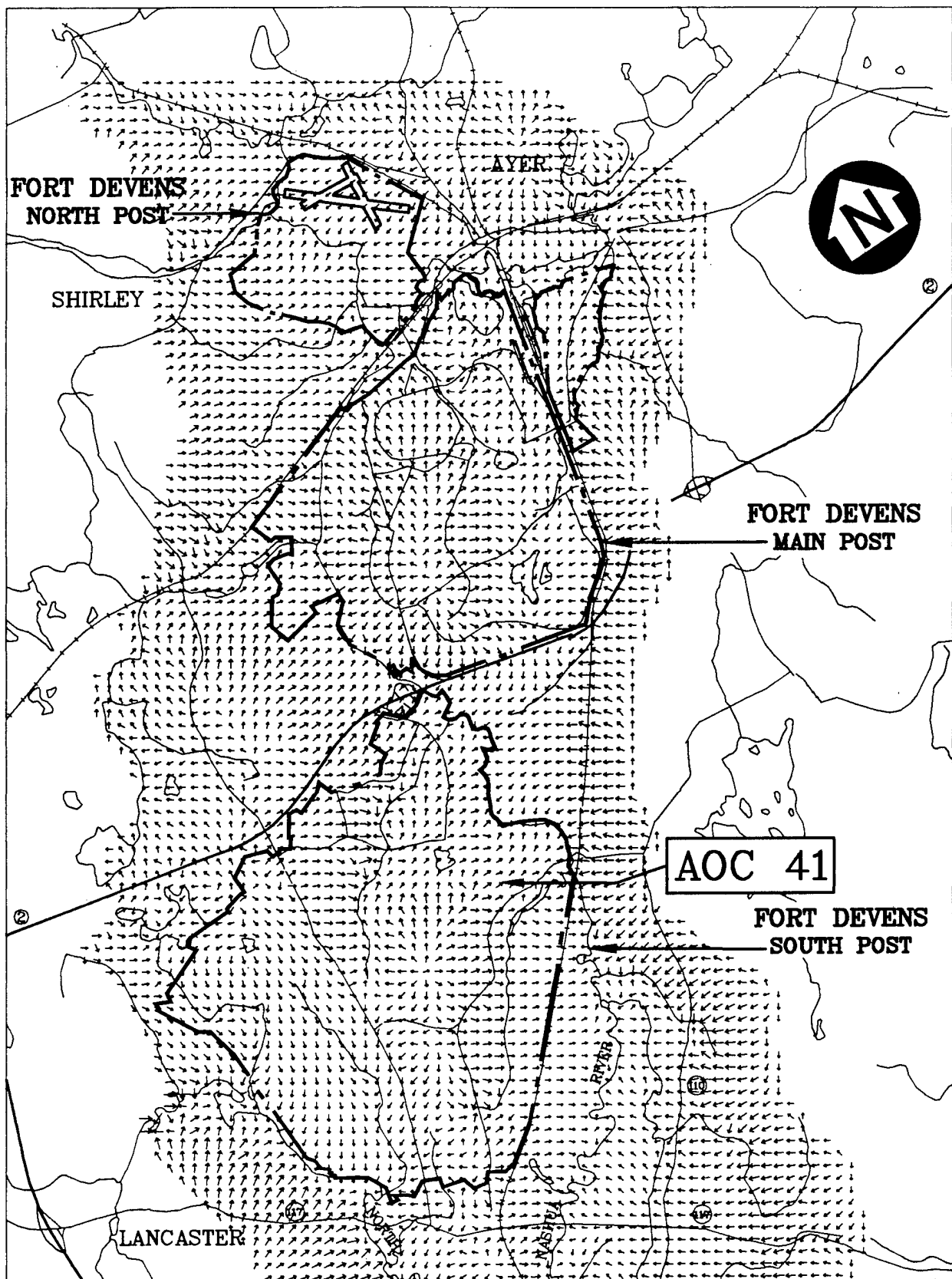
GROUNDWATER FLOW VECTORS

0 3000 6000 12000 FEET

SCALE: 1" = 6000'

AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ABB Environmental Services, Inc.



SOURCE:
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA,
ETA, INC. OCTOBER 30, 1992.

GROUNDWATER FLOW VECTORS

0 3000 6000 12000 FEET

SCALE: 1" = 6000'

FIGURE 2-7
REGIONAL BEDROCK
GROUNDWATER FLOW MAP
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

3.0 ANALYTICAL PROGRAM

Based on data obtained from previous investigations presented in the Final Site Investigation Report for Groups 2 and 7, Data Item A009 (ABB-ES, 1993a) and the Groups 2 and 7 SSI Data Package, (ABB-ES, 1994a), an analytical program was established to identify contaminants that were potentially present due to historic activities at AOC 41. Chlorinated solvent contaminants were discovered in past investigations at AOC 41.

The analytical program included field analysis as well as off-site laboratory analyses for a predetermined set of organic and inorganic analytes. The specific analyses implemented for these investigations are provided in Section 5.0 of this report and in the Revised Final Task Order Work Plan (ABB-ES, 1994b) and the Fort Devens Final POP (ABB-ES, 1993e). The following subsections describe the field and off-site analytical programs implemented for the 1992 through 1994 investigations completed by ABB-ES at AOC 41.

3.1 FIELD ANALYTICAL METHODS

Samples were analyzed in the field during each phase of the investigation (SI, SSI, and RI) to provide real time chemical data. Soil and groundwater samples from AOC 41 were analyzed for volatile organic compounds (VOCs). Data were primarily used to delineate the distribution of chlorinated solvents contamination in groundwater at this AOC. Target compounds and detection limits for field analysis compounds are outlined in Table 3-1 of this section. Samples submitted for field analysis included groundwater from monitoring wells and screened auger borings, and soil taken from test pits, TerraProbeSM points and soil borings.

A Hewlett Packard 5890 Series II gas chromatograph (GC), in series with a Tekmar 3000 purge and trap concentrator, was used to measure concentrations of VOCs in the different matrices. Several detectors were used in conjunction with the GC during the three field programs. Detectors included a flame ionization detector (FID), photoionization detector (PID), and electrolytic conductivity detector (ELCD). Target VOCs for AOC 41 measured on the FID and PID included benzene, toluene, ethylbenzene, m/p-xylene, and o-xylene (BTEX).

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During the 1994 RI, additional halocarbons were measured on the ELCD, including vinyl chloride, c-1,2-dichloroethene, t-1,2-dichloroethene, trichloroethene (TCE), tetrachloroethene (PCE), 1,2-dichlorobenzene, and 1,1,2,2-tetrachloroethane (1,1,2,2-TCA). These chlorinated compounds were identified as target compounds at AOC 41. The ability to detect them provided additional chemical data about the site.

3.1.1 Instrument Calibration

For analysis of samples for target compounds using a GC, an initial calibration was established. The initial calibration was accomplished through the analysis of three to five different concentrations of working standards. The response of the instrument to each standard was plotted versus the concentrations of standards to establish a calibration curve. The range of standards used to create the calibration curve was determined by the anticipated range of VOC contamination. A standard that contained all of the ELCD target compounds except vinyl chloride was used in concentrations of 2, 5, 10, 20 and 40 micrograms per liter ($\mu\text{g/L}$) to create a calibration curve. The calibration curve for vinyl chloride was created from standard runs of 10, 20, and 40 $\mu\text{g/L}$. A standard that contained all of the BTEX PID target compounds was used in concentrations of 2, 5, 10, 50, and 100 $\mu\text{g/L}$ to create a calibration curve. Once all points were established on the calibration curve, the linearity was measured using linear regression. The r^2 value, which provided a measure of this linearity, was required to be a minimum of 0.990. No field samples were analyzed until this condition was satisfied.

Prior to analysis of samples, a continuing calibration check standard was analyzed each day to ensure that the response of the instrument had not changed from the initial calibration. The concentration of the check standard was at mid-level in the calibration curve. The initial calibration remained valid if concentrations obtained for the target analytes were no greater than 30 percent different from values obtained from the initial calibration. The percent difference was allowed to be greater than 30 percent for one compound. If continuing calibrations did not meet this criterion, a new initial calibration was created.

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3.1.2 Sample Preparation and Analysis

Sample preparation techniques for GC VOCs were adapted from protocols outlined in USEPA Method 5030 and Method 8010/8020 (USEPA, 1986). Soil samples were prepared for field analysis by the measurement of 5 grams into a soil sparger. For water samples, the amount used was 5 mL. The sample was loaded onto the purge and trap concentrator. Helium was purged through the sample to carry compounds onto a cold, compound-capturing silica/charcoal trap. The trap was heated to 235°C to liberate volatile compounds into a DB-624 capillary column which was installed in the GC. The capillary column served the purpose of separating out the various compounds. An FID detector was used during the 1992 and 1993 field investigations. For the 1994 RI field analytical program, PID and ELCD detectors were located in series at the end of the column. The amount of time spent in the capillary column (retention time) by each compound was determined by its molecular weight and the temperature program of the GC. A retention time window of ± 3 percent was used for the identification of target compounds.

3.1.3 Target Compound Concentration Calculations

Target VOC concentrations were determined from comparisons of responses of compounds in samples versus responses from standards in the initial calibration curves described in Subsection 3.1.1. Soil compound concentrations were reported on a dry weight basis. The solid fraction of soil samples was determined by drying out the samples in an oven. The dry weight of the sample divided by the wet weight provided a solids fraction value. Solid fraction data was used to calculate final VOC concentrations. Dilutions performed on both water and soil samples also were used to calculate final VOC concentrations. Dilution factors were calculated for any analyses where sample amounts were modified due to high concentrations of chemicals present in samples. For VOC analyses, samples were prepared based on procedures outlined in USEPA Method 5030 (USEPA, 1986). Final sample results were calculated by dividing original unadjusted sample results by fraction of solid and multiplying results by any dilution factors.

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3.1.4 Field Documentation Procedures

Instrument logbooks were completed for each instrument used during each of the field analytical programs. A log of all chromatography runs was recorded in these logbooks. The logbooks recorded the concentrations for all calibration standards used, sample run number, sample identification, date, standard preparation records, instrument maintenance records, percent solid determination data, sample volume or weight, and any additional comments or observations of the field chemist. In addition, the results from each GC run were saved into a computerized database.

At the conclusion of field efforts for each investigation, raw data from the GC analyses and instrument logbooks were transferred for storage at ABB-ES's Portland, Maine office. Raw data includes chromatograms, quantitation reports, and instrument and notebook records to document analyses.

3.1.5 Field Analytical Quality Control

A QC program for the field analytical results was established prior to commencement of each investigation. Field analysis using an on-site laboratory was conducted during 1992, 1993, and 1994 field programs. Each program was developed to ensure that the data generated at the field laboratory was of sufficient quality to be considered satisfactory for its intended use. QC parameters for the 1994 RI field analytical program included initial and daily calibration check standard runs, an independent check standard evaluation, mid-level check standards after every ten samples, low-level and mid-level method blanks, cleaning blanks, matrix spikes and field or laboratory duplicates. The QC program which was implemented during the SI in 1992 and the SSI in 1993 was identical to the RI field program except that matrix spike and duplicate samples were not analyzed, and continuing calibration check standards were only run once per day. QC objectives for the on-site laboratory analyses are outlined in the Fort Devens POP (ABB-ES, 1992) and Appendix H. QC sample results for the on-site laboratory are discussed in Appendix H.

Instruments were calibrated using initial calibration procedures outlined in Subsection 3.1.1. Daily calibration checks were completed to ensure that the response of the detectors on the GC did not change significantly enough to

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compromise reported concentrations. If the reported concentration was greater than 30 percent different from the actual concentration for all but one of the target compounds, then a new calibration curve was established.

Beginning in the 1994 RI, an independent check standard was prepared from neat standards of the VOC target compounds obtained from a different chemical supplier than those used to prepare the working standards. The purpose of completing analysis of this standard was to determine the analytical precision of the method and to confirm that there was good precision in the preparation of the standards. A mid-level concentration of this standard was analyzed and compared to the calibration curve established using the working standard. The concentrations of the target compounds from the independent check standard were required to be within thirty percent of the mid-point concentration established using the working standard. Results from the independent check standard analysis are contained in Appendix H.

Method blanks were analyzed daily to document that the analytical system was free of contamination. Samples were not run if there were any target compounds detected above the Practical Quantitation Limit (PQL) in the method blank. In addition to the low-level method blank, a mid-level method blank was run in instances where methanol extractions were necessary. One hundred microliters of methanol were added to deionized water and analyzed to ensure that it was free of contamination.

During VOC GC analyses, cleaning blanks were run at the beginning of each day to show that the analytical system was clean. They also were run after particularly heavily contaminated samples were run through the GC.

During the 1994 RI program, matrix spikes were analyzed to determine if the soil or water matrix had any influence in retarding or enhancing the concentrations of target compounds. A sample was first run to determine baseline values of the target compounds. Known concentrations of a mix of the target compounds were added to a sample and analyzed as a regular sample. The reported concentrations were adjusted by subtracting the baseline concentration of a particular analyte which was measured in the sample before it was spiked. This result was then divided by the actual concentrations at which analytes were spiked

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and multiplied by 100 to calculate the percent recovery. Matrix spike results for 1994 RI field analyses are presented in Appendix H.

For VOC analyses, a surrogate was added to every sample to determine if the matrix was having an effect on the recovery of the target compounds. The surrogate used for all field investigations was 4-bromofluorobenzene. This surrogate was used because it is chemically similar to the target compounds and responds well on the detectors selected for the field programs. Surrogate recoveries had to be from 30 percent to 170 percent to be considered acceptable. Samples for which the surrogate did not meet this criterion were reanalyzed.

Field duplicate samples were also analyzed to determine the precision of sampling and analytical techniques. Reported concentrations of target compounds for each sample and associated duplicate pair were compared by calculating the relative percent difference (RPD) of the results. RPDs were compared to criteria from USEPA Region 1 validation guidelines to evaluate the precision of measurements. Duplicate results for the 1994 RI are presented in Appendix H.

3.1.6 Method Detection Limits and Data Qualifiers

Method Detection Limits (MDLs) were established during the 1994 RI for both the ELCD and PID detector target compounds. MDLs were also established for the FID during the SSI completed in 1993. The MDL study was completed for all VOC target compounds to provide data to support the PQLs established for the various field programs. MDLs were calculated based on procedures published in CFR Appendix B Part 136, vol. 49, no. 209. The MDL study provides an estimation of the lower concentration limit of what the detectors were able to measure. The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. They were determined by running seven consecutive runs of a premixed standard at a concentration believed to be near the threshold of detection. The concentration used for all target compounds in the MDL study was 2 $\mu\text{g/L}$.

Once the seven low-concentration runs of the standard were completed, the mean and standard deviation were calculated for the area counts reported by the

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instrument. These values were inserted into the equation below to determine the MDL.

$$MDL = \frac{\text{standard deviations of peak area} \times 3.14 \text{ (student } t \text{ number for 7 runs)}}{\text{mean peak area}}$$

The MDLs obtained during the 1994 RI field analytical program are presented in Table 3-1.

PQLs were established to provide a margin of error from the MDL since the MDL identifies the threshold concentration of what the detector was capable of measuring. MDLs were conducted during the SSI and RI phases of the investigation to provide a high level of data quality and dependability of field analytical results. PQLs for the 1992, 1993, and 1994 programs are outlined on Table 3-1. PQLs were used as reporting limits for field sample results during the 1994 RI. In the 1993 SSI, MDLs served as reporting limits.

In some instances, data qualifiers were used to address data quality issues associated with a particular sample. The following qualifiers were used during SI, SSI, and RI at Fort Devens:

E - Denotes target compound concentrations that exceeded the highest standard of the calibration curve.

U - Denotes sample concentrations that are less than PQLs or MDLs.

Results of the on-site sample analyses are presented in discussions of the nature and distribution of site contaminants presented in Section 7.0 of this report and Appendix M-1.

3.2 OFF-SITE LABORATORY ANALYTICAL PARAMETERS

Soil and groundwater samples collected from AOC 41 were analyzed at an off-site laboratory for chemical parameters on the Fort Devens Project Analyte List

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(PAL). Off-site laboratory analyses for PAL organics and inorganics were considered approximately equivalent to USEPA Level III quality data. The Fort Devens PAL and laboratory methods are presented in the Fort Devens POP (ABB-ES, 1993c) and Appendix K of this report.

Laboratories performing the analytical work for all AOC 41 investigations have been required to implement the 1990 USATHAMA (now USACE) QA Program (USATHAMA, 1990). All method performance demonstrations, data management, and oversight for previous USATHAMA analytical procedures are currently performed by the USAEC.

The off-site laboratory contracted to implement the analytical program for all phases of investigation at AOC 41 was Environmental Science and Engineering, Inc. (ESE). This laboratory was approved to complete analyses using USATHAMA and USEPA methods. These analyses were completed while implementing the 1990 USATHAMA QA Program. Specific performance demonstration and QC components of the 1990 USATHAMA QA Plan are detailed in Subsection 3.2.3 of this report.

The following subsection describes the procedures implemented to achieve the objectives of the QA program and any additional QC processes implemented during the SI, SSI and RI.

3.2.1 Off-Site Laboratory Certification

In accordance with the 1990 USATHAMA QA Program, laboratories were required to demonstrate competency by performance demonstration of the PAL analytical methods conducted in association with field investigations. The USAEC requires that a laboratory demonstrate proficiency in performing USAEC methods for specific analytes. Analytical methods are based on USEPA procedures (USEPA 1983; 1986). Laboratories demonstrate proficiency by submitting data from runs of pre-certification calibration standards. Performance samples are then sent for analysis to the laboratory by the USAEC. The true concentrations of the analytes in the performance samples are unknown by the laboratory. The data obtained from the analyses of these samples are then sent to the USAEC to determine the laboratory's precision and accuracy. Qualifications to perform USAEC methods are awarded to laboratories based on this performance.

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Certified Reporting Limits (CRLs) are also determined through this process. A method code associated with each USAEC analysis and laboratory is then assigned and reported with the results.

For some methods such as alkalinity, total organic carbon (TOC), total petroleum hydrocarbons (TPHC), and total suspended solids (TSS), there are no associated USAEC methods. The USAEC recognizes standard USEPA protocols or internal laboratory methods for these analyses. Laboratories are required to submit information on procedures for analyzing samples using these methods to the USAEC Chemistry Branch before they are implemented.

3.2.2 Off-Site Laboratory Methods Quality Control

All field samples sent to ESE were organized into lots which were assigned a three letter code. Each lot consisted of the maximum number of samples, including QC samples, that can be processed through the rate limiting step of the method during a single time period (not exceeding 24 hours). Associated with each lot were laboratory control samples. Control samples were spikes of high and low concentrations of specific analytes that help monitor ESE's laboratory precision and accuracy. The recoveries of these spikes were plotted on control charts generated by ESE and submitted to the USAEC. Data generated during the performance demonstration process were used to calculate a mean of the recoveries. Control and warning limits were statistically generated by the USAEC Chemistry Branch to help measure laboratory data quality. Control charts are generated with each lot providing a continuous benchmark for trend evaluation of laboratory performance.

Method blanks were also analyzed at ESE to evaluate the potential for target analytes to be introduced during the processing and analysis of samples. One method blank was included with each analytical lot. Because analytical lots included samples from several areas, method blank results are presented and discussed by year of investigation for AOC 41 in Appendix H. Only method blank data associated with samples from AOC 41 were used for the QC report.

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3.2.3 Data Reduction, Validation, and Reporting

Initial responsibility for accuracy and completeness of Fort Devens analytical data packages was with ESE. All data submissions to the USAEC first underwent a review process. This review included checks on the data quality which evaluated completeness of the ESE data, accuracy of reporting limits, compliance with QC limits and holding times, and correlation of ESE data to associated laboratory tests.

The following items were also validated by ESE before submission to the USAEC:

- COC records;
- instrument printouts for agreement with handwritten results;
- calibration records to ensure a particular lot is associated with only one calibration;
- chromatograms and explanations for operator corrective actions (such as manual integrations);
- standard preparation and documentation of source;
- calculations on selected samples;
- notebooks and sheets of paper to ensure all pages were dated and initialed, and explanations of procedure changes;
- GC/MS library search of unknown compounds; and
- transfer files and records to ensure agreement with analysis results.

To document the data review and validation process, a data-review checklist was submitted as part of each data package.

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3.2.4 Data Reporting

After review and validation by ESE, the data were encoded for transmission into the USAEC's Installation Restoration Data Management Information System (IRDMIS) as Level 1 data. IRDMIS, a computerized data management system used by the USAEC, is described in detail in Subsection 3.3. Once the data were entered into the system, a group and records check was completed. Data were then transferred to USAEC's data management contractor. During this phase, the data were elevated to Level 2. Another group and records check was performed and the data were reviewed by the USAEC Chemistry Branch. When errors were identified, the data were returned to ESE for correction. Control charts were produced by ESE that plotted recoveries of high and low concentrations of laboratory control spikes of the target analytes. The control charts provided the USAEC with information about the accuracy of the analytical methods performed by ESE. Once data were reviewed by the USAEC Chemistry Branch, the determination was made on a lot-by-lot basis whether the data were acceptable. The data that were accepted were then elevated to Level 3 and made available to USAEC personnel and ABB-ES by modem to a main frame computer. Off-site results are presented in Section 7.0 and Appendix M.

3.2.5 Field Quality Control Samples

Field QC samples which were collected during various investigations conducted at AOC 41 included a field blank (source water), matrix spikes/matrix spike duplicates (MS/MSDs), field duplicate samples, rinsate blanks and trip blanks.

Before field investigations were initiated at AOC 41, a sample of water was collected from the source which was used for sampling equipment decontamination. The water source for each field investigation at AOC 41 was the South Post Water Point (Well D-1). For the purpose of laboratory QC, this was identified as the field blank (source water sample). The field blank data were sent to the USAEC Chemistry Branch where approval was granted for the use of this water in decontamination procedures. The information gained from the analysis of the field blank provided data on the quality of the USAEC-approved water used in the decontamination of the sampling equipment. Field blank data were also used to explain the presence of certain analytes or compounds in rinsate

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blanks. Several field blanks were collected between 1992 to 1994. All field blank data are discussed with the 1992 QC data in Appendix H.

As specified in the Fort Devens POP, (ABB-ES, 1993e), MS/MSDs were spiked and analyzed for PAL inorganics, explosives, and/or pesticides/polychlorinated biphenyl (PCBs). ABB-ES personnel made the determination of which samples were to be designated as MS/MSDs. This was noted on the COC forms submitted to ESE. Samples designated as MS/MSDs were spiked at the off-site laboratory with specified concentrations or analytes to determine matrix effects based on USAEC and USEPA method guidelines. MS/MSD data were also used to assess the accuracy of the analyses used. MS/MSD samples were collected at a rate of one set per 20 samples. During the Fort Devens field investigations, samples were collected from multiple SAs or AOCs. After the twentieth sample was collected, a sample from any SA may have been designated for MS/MSD analysis. The MS/MSD samples were collected and analyzed at the specified frequency program-wide and not for specific SAs or AOCs. Therefore, assessments of MS/MSD data contained in Appendix H were not made specifically for AOC 41, but are discussed by year for AOCs 43J, 43G, and 41, collectively.

Field duplicate samples were also collected at a rate of one per 20 field samples. The purpose of duplicate sample analysis was to assess the sampling and off-site laboratory precision for particular methods. Since several SAs or AOCs were investigated simultaneously during each field efforts designations for duplicate samples covered multiple SAs or AOCs. Duplicate data which was available for AOCs 43G, 43J, and 41 were assessed collectively by year of investigation. Duplicates submitted to ESE were analyzed for the same compounds as the corresponding field samples. Duplicate sample results are presented in Appendix H.

Rinsate blanks were collected and analyzed for PAL analytes. Rinsate blanks consisted of previously analyzed deionized water which was poured over sampling equipment. Analysis of this water provided information used to evaluate the potential for sample contamination during sample collection. The results were also used to assess decontamination of the sampling equipment. As specified in the Fort Devens POP (ABB-ES, 1993e), rinsate blanks were collected at a rate of one per 20 samples. Rinsate blank data associations were not made specifically

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for AOC 41. Rinsate blanks which were shipped with any samples from AOCs 43G, 43J, or 41 were included in the data quality reports. Therefore, the discussions regarding rinsate blank contamination are relevant to all three AOCs rather than one specific AOC. Rinsate blank results were segregated by year of investigation and are presented in Appendix H.

For every shipment of VOC samples to ESE, there was accompanying trip blanks that traveled with the samples. The purpose of analyzing trip blanks was to determine if there was any VOC cross contamination during the shipment and handling of samples. The trip blanks consisted of previously analyzed deionized water that was bottled at ESE. Trip blanks were shipped in sealed containers to the job site. As needed, trip blanks were then included with shipments of VOC field samples. Because many of these VOC field samples were taken from various AOCs, there is no association of trip blank data specifically to AOC 41. Data were included for trip blanks sent with any samples from AOCs 43G, 43J, and 41. Trip blank assessments were separated by the year of investigation. All trip blank data are presented in Appendix H.

3.2.6 Off-Site Analytical Data Quality Evaluation

Laboratory data collected during the three investigations at Fort Devens were evaluated for possible laboratory or sampling-related contamination. This evaluation did not include validation according to USEPA guidelines. Sample results reported and discussed in this report were not adjusted for reported analytes that were also detected at similar concentrations in blanks associated with that sample; action levels were not established, and the 10X rule was not applied to compounds considered by the USEPA to be common laboratory contaminants. Examples of these contaminants include the VOCs acetone, methylene chloride, 2-butanone, and the semivolatile organic compounds (SVOCs) bis (2-ethylhexyl)phthalate (BEHP) and di-n-butylphthalate. Likewise, action levels for other analytes using the 5X rule application were not established. Analytes that would have been below these action levels were not removed from the data as they would have been in the USEPA validation process.

General trends relating to blank and sample contamination were examined. Comparison of blank data with results from the entire data set are discussed as a data assessment. Assessments are made based on analyte detection in blanks, the

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frequency of the detection and the concentrations of these analytes. A summary of blank contamination was completed and is presented in Subsection 7.1.2 of this report.

3.3 CHEMICAL DATA MANAGEMENT

Chemical data from the AOC were managed by ABB-ES' Sample Tracking System and the USAEC's IRDMIS. These systems are described in the following sections.

3.3.1 Sample Tracking System

ABB-ES employed its computerized Sample Management System to track environmental samples from field collection to shipment to the off-site laboratory. ABB-ES also tracked the status of analyses and reporting by the off-site laboratory.

Each day the field sampling teams carried computer-generated sample labels into the field that stated the sample control number, sample identification, size and type of container, sample preservation summary, analysis method code, and sample medium. The labels also provided space for sampling date, time, depth (if applicable), and the collector's initials to be added at the time of collection.

After collection in the field, the samples were stored on ice for transport back to the ABB-ES field office. Samples were temporarily stored in the ABB-ES field office refrigerator. They were checked-in on the field office computer, and the collector's initials and the sampling date and time were entered. The system would then indicate the sample status as "COLLECTION IN PROGRESS."

When the samples were prepared for shipment, they were "RELEASED" by the sample management system. Upon request, the system printed an Analysis Request Form (ARF) and a COC, which were signed and included with the samples in the shipment. The system would then indicate the sample status as "SENT TO LAB."

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This system substantially reduced the time required for preparation of sample tracking documentation, and it provided an automated record of sample status.

After shipment of samples to the off-site laboratory, ABB-ES continued to use the sample tracking system to track and record the status of the samples, including the date analyzed (to determine actual holding times), the date a transfer file was established by ESE, and the date the data were sent to IRDMIS (Subsection 3.3.2).

3.3.2 Installation Restoration Data Management Information System

IRDMIS is an integrated system for collection, validation, storage, retrieval, and presentation of data of the USAEC's Installation Restoration and Base Closure Program. It uses personal computers (PCs), a UNIX-based minicomputer, printers, plotters, and communications networks to link these devices.

For each sample lot, ABB-ES developed a "provisional" map file for the sample locations, which was entered into IRDMIS by Potomac Research, Inc. (PRI), USAEC's data management contractor.

Following analysis of the sample lot, ESE created chemical files using data codes provided by ABB-ES, and entered the analytical results (Level 1) on a PC in accordance with the User's Manual (PRI, 1993). For each sample lot, a hard copy was printed and was reviewed and checked by ESE's Laboratory Program Manager. ESE created a transfer file from accepted records which was sent to ABB-ES (Level 2). ABB-ES performed a group and record check and sent approved records in a chemical transfer file to PRI. PRI checked the data and, if accepted, entered it into the IRDMIS minicomputer (Level 3). Level 3 chemical data are the data used for evaluating site conditions, and are the data used in this AOC 41 RI report.

TABLE 3-1
1994 FIELD ANALYTICAL MDLs and PQLs FOR TARGET COMPOUNDS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

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Compound	Year	MDL (ug/L)	PQL (ug/L; ug/kg)
Vinyl Chloride	1994	2.07	4.0
t-1,2-Dichloroethene	1994	0.19	2.0
c-1,2-Dichloroethene	1994	0.15	2.0
TCE	1994	0.19	2.0
PCE	1994	0.19	2.0
1,1,2,2-TCA	1994	2.1	4.0
1,2-Dichlorobenzene	1994	0.23	2.0
Benzene	1992-1994	0.22	2.0
Toluene	1992-1994	0.19	2.0
Ethylbenzene	1992-1994	0.16	2.0
m/p-Xylene	1992-1994	0.33	2.0
o-Xylene	1992-1994	0.18	2.0

4.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS IDENTIFICATION

CERCLA was enacted by Congress in 1980, establishing the Superfund program. The regulations implementing this program are found in 40 CFR Part 300, also known as the National Contingency Plan (NCP). CERCLA was amended in 1986 by the SARA, which mandated that the level or standard of control specified in a remedial action be "at least that of any ARAR standard, requirement, criteria, or limitation under any federal environmental law, or any more stringent standard, requirement, criteria, or limitation promulgated pursuant to a state environmental statute." SARA established that the requirements of the NCP apply to federal facilities.

The purpose of the RI was to determine the nature and distribution of site-related groundwater contamination at AOC 41. In order to evaluate whether there is a potential threat to human health and the environment, the preliminary ARARs identified in this section have been compared to site-specific data. ARARs are federal and state human health and environmental requirements used to (1) evaluate the distribution of site impacts and the appropriate extent of site cleanup; (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the final remedy.

Identification and evaluation of ARARs is an iterative task, necessary throughout the remedial response process. Therefore, the preliminary lists of requirements identified for AOC 41 and their relevance may change as more information is obtained and as the preferred alternative is chosen. For the time being, it is assumed that natural attenuation for groundwater will be the remedial action because the Army's future use for this area will be the same as its present use. Because of this, there is no present or future residential groundwater exposure point risk.

ARARs are classified into three categories: chemical-, location-, and action-specific. The following subsections provide an overview of these ARARs. Because no remedial action is anticipated for AOC 41, there is no need for a location-specific and action-specific ARARs analysis. The chemical-specific ARARs, which are pertinent to evaluating the constituent concentrations in the

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groundwater, are listed in Table 4-1. Chemical-specific ARARs generally involve health- or risk-based numerical values or methodologies that establish site-specific acceptable chemical concentrations or amounts. These values are used to develop action levels or cleanup concentrations.

4.1 GROUNDWATER

Table 4-1 sets forth the federal chemical-specific ARARs and to be considered (TBC) information for groundwater. The USEPA Safe Drinking Water Act (SDWA) MCLs are legally applicable to contaminants found in public water systems that have at least 15 service connections or serve an average of at least 25 people daily at least 60 days per year. Even when not legally applicable, MCLs may be relevant and appropriate to groundwater remediation. Maximum contaminant level goals (MCLGs) are non-enforceable, health-based goals at which no known or anticipated adverse effects on health will occur. Table 4-1 also includes the USEPA Region III risk-based concentrations (RBCs), which are commonly used as TBC information at CERCLA sites nationwide. The surface water criteria set forth in Table 4-1 are TBC information and will only be applicable if a discharge to surface water will be part of the groundwater remedial action (which is not expected).

Table 4-2 sets forth the state chemical-specific ARARs and TBC information for groundwater. The Commonwealth of Massachusetts has adopted drinking water standard and guidelines, expressed in terms of maximum levels of contaminants allowed in drinking water. Groundwater data from AOC 41 will be compared to Massachusetts maximum contaminant levels (MMCLs), Massachusetts Class I groundwater quality standards, and/or USEPA Region III RBCs for tap water.

Even though groundwater contaminant concentrations at AOC 41 exceed federal MCLs, it is anticipated that the site-related contaminants will not be impacting on-post or off-post residential drinking water sources, due to the local and regional hydrologic conditions. Therefore, action-specific and location-specific ARARs are not included in this report.

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4.2 SOIL

Soil analytical results and associated health risks for AOC 41 will not be addressed in this RI but will be addressed separately under the Fort Devens Consolidation Landfill FS Report. Potential ARARs will be the soil screening levels for protection of air and groundwater provided in the USEPA Region III RBC guidance document.

4.3 MASSACHUSETTS CONTINGENCY PLAN

The NCP provides that CERCLA response actions must comply with environmental and public health laws and regulations to the extent they are substantive (i.e., pertain directly to actions or conditions in the environment), but do not need to comply with those which are administrative (i.e., mechanisms that facilitate the implementation of the substantive requirements).

The provisions of the MCP, 310 CMR 40.0000 (January 13, 1995) are mostly administrative in nature and, therefore do not have to be complied with in connection with the response action selected for AOC 41. Further, the MCP contains a specific provision (310 CMR 40.0111) for deferring application of the MCP at CERCLA sites. As stated in the MCP, response actions at CERCLA sites are deemed adequately regulated for purposes of compliance with the MCP, provided the MADEP concurs in the CERCLA Record of Decision (ROD).

However, some provisions of the MCP contain substantive requirements that may be ARARs. Provision 310 CMR 40.0940 sets forth three methods of risk characterization. Provision 310 CMR 40.0942 provides that any of the three methods may be used, subject to certain specified limitations. MCP Method 1 establishes specific numerical standards for certain listed contaminants (see 310 CMR 40.0974-.0975). Since MCP Method 1 contains promulgated numerical standards, it may be an ARAR if this method is selected.

MCP Method 3 does not contain substantive numerical standards; rather it provides a risk characterization methodology to determine the appropriate cleanup level (see 310 CMR 40.0991-.0996). Because MCP Method 3 is a methodology and does not contain substantive standards, and because it defines

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protectiveness in a way which is inconsistent with the CERCLA NCP, Method 3 is not an ARAR that has to be met. Therefore, these standards of the MCP do not apply to the remedial response at AOC 41.

4.4 BACKGROUND CONCENTRATIONS

As a means of evaluating concentrations of inorganic analytes detected in samples collected as part of all phases of investigation, background concentrations were calculated for the Fort Devens installation as a whole. Background concentration calculations were based on analytical data results gathered from soil and groundwater samples collected throughout the Fort Devens installation, and were selected as representative of background (non-contaminated) conditions. Although most of the calculations include assumptions on both the distribution of chemical concentrations and on the selection of representative samples that are not statistically rigorous, the results are considered conservatively representative of actual background concentrations at Fort Devens.

For soil, chemical data gathered from 33 soil samples collected by Ecology & Environment, Inc. (E&E) from 1991 to 1993. The samples were collected from the major soil associations throughout Fort Devens specifically to establish background concentrations of inorganic analytes in soil. The background soil samples were collected from locations that were visually undisturbed, at least 50 feet from any road, and 300 feet from any known SA.

The calculations were performed on 22 of the 23 PAL inorganic analytes (no data were available for thallium). For analytes that were not detected in the majority of soil samples, the detection limit for that analyte was selected as the background concentration. Sample location, data ranges, mean values, details of calculations, and calculated background concentrations are summarized in Appendix L.

For the purpose of calculating background inorganic analyte concentrations in groundwater, ABB-ES selected 10 representative groundwater samples collected from the Round One groundwater sampling events completed in 1992 for Groups 2, 3, 5, 6 and 7. Representative groundwater samples were selected from specific monitoring wells located upgradient of an SA, exhibiting low TSS and/or low aluminum concentrations. Aware that elevated TSS concentrations artificially

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elevate inorganic analyte concentrations, ABB-ES selected samples that exhibited TSS concentrations on the same order of magnitude as the South Post Water Point (Well D-1) (i.e., representative of typical TSS concentrations in potable groundwater). Because a close correlation between TSS concentrations and aluminum concentrations was observed in all the groundwater samples analyzed, the aluminum concentration was used as an alternate selection criterion in the absence of TSS data. The concentration values detected in the 10 samples were calculated using the same assumptions on outliers and detection limits applied to the soils background concentration calculations. The statistical analysis calculations for groundwater inorganics, and the resulting background concentrations, data ranges, mean values, calculated background concentrations, and details of the calculations are also provided in Appendix L.

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
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Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) ^(a)		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) ^(b)			TBC Region III Tap Water (µg/L)
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	For Protection of Human Health		For Protection of Aquatic Life	
			ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Volatile Organics						
acetone	-	-	-	-	-/-	3,700N
benzene	5	zero	0.66	40	5,300/- ²	0.36C
carbon tetrachloride	5	zero	0.4	6.94	35,200/- ²	0.16C
chloroform (THM)	100/80 ³	zero	0.19	15.7	28,900/1,240 ²	0.15C
ethylbenzene	700	700	1,400	3,280	32,000/- ²	1,300N
styrene	100	100	-	-	-/-	1,600N
1,1,2,2-tetrachloroethane	-	-	0.17	10.7	-/2,400 ²	0.052C
tetrachloroethylene	5	zero	0.8	8.85	5,280/840 ²	1.10C
toluene	1,000	1,000	14,300	424,000	17,500/- ²	750N
1,1,1-trichloroethane	200	200	18,400	1,030,000	-/-	1,300N
trichloroethylene	5	zero	2.7	80.7	45,000/21,900 ²	1.6C
trichlorofluoromethane	-	-	-	-	-/-	1,300N
xylenes (total)	10,000	10,000	-	-	-/-	12,000N

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) ^(a)		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) ^(b)		TBC Region III Tap Water (µg/L)	
			For Protection of Aquatic Life			
	For Protection of Human Health		ARAR Fresh Water Acute/Chronic (µg/L)			
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)		ARAR Water and Fish Consumption (µg/l)		ARAR Fish Consumption Only (µg/L)
Semivolatile Organics						
acenaphthene	-	-	-	-	-/-	2,200N
anthracene	-	-	-	-	-/-	11,000N
bis(2-ethylhexyl)phthalate	6	zero	-	-	-/-	4.80C
benzo(a)anthracene	-	-	-	-	-/-	0.0092C
benzo(a)pyrene	2	zero	-	-	-/-	0.092C
benzo(b)fluoranthene	-	-	-	-	-/-	0.092C
benzo(g,h,i)perylene	-	-	-	-	-/-	-
benzo(k)fluoranthene	-	-	-	-	-/-	0.92C
benzyl alcohol	-	-	-	-	-	11,000N
carbazole	-	-	-	-	-/-	3.4C
chrysene	-	-	-	-	-/-	9.2C
dibenzofuran	-	-	-	-	-/-	150N
di-n-butyl phthalate	-	-	-	-	-	3,700N

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

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Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) ^(a)		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) ^(b)			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
fluoranthene	-	-	-	-	-/-	1,500N
fluorene	-	-	-	-	-/-	1,500N
indeno(1,2,3-c,d)pyrene	-	-	-	-	-/-	0.092C
2-methylnaphthalene	-	-	-	-	-/-	-
naphthalene	-	-	-	-	2,300/620 ²	1,500N
n-nitrosodiphenylamine	-	-	4.9	16.1	-/-	14C
phenanthrene	-	-	-	-	30/6.3 ³	-
pyrene	-	-	-	-	-/-	1,100N
Inorganics						
aluminum	-	50 to 200 ⁸			-/-	37,000N
antimony	6	6 ⁵	146	45,000	88/30 ⁵	15N
arsenic	50 ¹	-	0.0022	0.0175	360/190 ^{2,7}	11N/0.038C
barium	2,000	2,000	1,000		-/-	2,600
beryllium	4 ⁴	4	0.0037	0.0641	130/5.3 ²	0.016C

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) ^(a)		Clean Water Act (CWA)			TBC Region III Tap Water (µg/L)
			Ambient Water Quality Criteria (AWQC) ^(b)			
	For Protection of Human Health		For Protection of Aquatic Life			
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
cadmium	5	5	10	-	3.9/1.1 ⁴	18N
calcium	-	-			-/-	-
chromium (total)	100	100	-	-	1,700/210 ^{4,9}	180
cobalt	-		-	-	-/-	2,220
copper	TT ¹⁰	1,300	-	-	18/12 ⁴	1,400N
iron	-	300 ⁸	300	-	-/1,000	-
lead	TT ¹¹	zero	50	-	83/3.2 ⁴	-
magnesium	-	-	-	-	-/-	-
manganese	-	50 ⁸	50	100	-/-	180N
mercury	2	2	0.144	0.146	2.4/0.012	11N
nickel	100 ⁵	100 ⁵	13.4	100	1,400/160 ⁴	730N
potassium	-		-	-	-/-	-
selenium	50	50	10	-	20/5	180N
silver	-	100 ⁸	50	-	4.1/0.12 ^{4,6}	180N

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) ^(a)		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) ^(b)			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
sodium	-		-	-	-/-	-
vanadium	-					260N
zinc	-	5,000 ⁸	-	-	12/110 ⁴	11,000N
Pesticide/PCBs						
DDT	-	-	.000024	.000024	1.1/0.001	0.2C
DDD	-	-	-	-	-/-	0.28C
DDE	-	-	-	-	1,050/- ²	0.2C
endrin	2	2	1.0	-	0.18/.0023	11N
alpha chlordane	2 ¹³	zero ¹³	0.00046 ¹³	0.00048 ¹³	2.4/0.0043 ¹³	0.052 ¹³
gamma chlordane	2 ¹³	zero ¹³	0.00046 ¹³	0.00048 ¹³	2.4/0.0043 ¹³	0.052C ¹³
heptachlor	0.4	zero	0.00028	0.00029	0.52/.0038	0.0023C
PCB 1248	0.5 ¹⁴	zero ¹⁴	0.000079 ¹⁴	0.000079 ¹⁴	2.0/0.014 ¹⁴	0.0087C
PCB 1254	0.5 ¹⁴	zero ¹⁴	0.000079 ¹⁴	0.000079 ¹⁴	2.0/0.014 ¹⁴	0.73N
PCB 1260	0.5 ¹⁴	zero ¹⁴	0.000079 ¹⁴	0.000079 ¹⁴	2.0/0.014 ¹⁴	0.0087C ¹⁴

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
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Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) ^(a)		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) ^(b)			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Explosives						
cycloetramethylenetetranitramine (HMX)	-	-	-	-	-	-
cyclonite (RDX)	-	-	-	-	-	-
2,4-dinitrotoluene	-	-	-	-	-	73N
2,6-dinitrotoluene	-	-	-	-	-	37N
nitroglycerine	-	-	-	-	-	-
2,4,6-trinitrotoluene	-	-	-	-	-	2.2C
Cations/Anions						
chloride		250,000 ⁸	-	-	860K /230K	-
phosphate	-	-	-	-	-/-	-
sulfate	-	500,000 ¹⁵ /250,000 ⁸	-	-	-/-	-
alkalinity	-	-	-	-	- /20,000	-

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
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Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA) ^(a)		Clean Water Act (CWA)			TBC Region III Tap Water (µg/L)
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	Ambient Water Quality Criteria (AWQC) ^(b)		For Protection of Aquatic Life	
			For Protection of Human Health	For Protection of Aquatic Life		
			ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Other						
nitrate/nitrite as N	10,000/1,000 ¹²	-	10,000/-			58,000N/3,100N
TPH	-	-				-

Notes:

(a) USEPA, "Drinking Water Standards and Health Advisories", Office of Water, Washington, D.C.; May 1995.
 (b) USEPA, "Water Quality Criteria Summary", Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C.; May 1, 1991; criteria shown for carcinogens present a one-in-a-million incremental risk.

- CWA = Clean Water Act
 MCL = Maximum Contaminant Level
 MCLG = Maximum Contaminant Level Goal
 1 MCL for arsenic currently under review.
 2 Insufficient data to develop criteria. Value presented is the Lowest Observed Effect Level (LOEL).
 3 1994 Proposed rule for Disinfectants and Disinfection By-Products: Total for all THMs combined would not exceed the 80 µg/L level.
 4 Hardness dependent criteria (100 mg/L CaCO₃ used).
 5 Standard is being remanded.
 6 Proposed level, freshwater acute - 0.92 µg/L.
 7 Values presented are for trivalent species.
 8 Non-enforceable secondary regulation based on aesthetics (e.g., color, odor, taste).
 9 Values presented are for hexavalent chromium species.
 10 Treatment technique action level 1,300 µg/L.
 11 Treatment technique action level 15 µg/l; concentration measured at tap.
 12 Nitrate or nitrite as nitrogen; standard total nitrate and nitrite is 10,000 µg/l.
 13 Values reported for chlordane (CAS #57-74-9)
 14 Values reported for total PCBs (CAS #1336-36-3)
 15 Proposed criteria.
- TT = Treatment technique required.
 µg/L = micrograms per liter
 - = No federal or state guidance criteria or standards exist.
 N = Noncarcinogenic effects representing an HQ of 1.0.
 C = Carcinogenic effects representing a cancer risk of 10⁻⁶.

TABLE 4-2
STATE ARARS AND TBC GUIDANCE - GROUNDWATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

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ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER ^(a) (µG/L)	CLASS I GROUNDWATER ^(b) (µG/L)
Volatile Organics		
acetone	3000 ²	-
benzene	5	-
carbon tetrachloride	5	-
chloroform	5 ²	100 ³
ethylbenzene	700	-
styrene	100	-
1,1,2,2-tetrachloroethane	-	-
tetrachloroethylene	5	-
toluene	1000	-
1,1,1-trichloroethane	200	-
trichloroethylene	5	-
trichlorofluoromethane	-	-
xlenes (total)	10,000	-
Semivolatile Organics		
acenaphthylene	-	-
anthracene	-	-
bis(2-ethylhexyl)phthalate	6	-
benzo(a)anthracene	-	-
benzo(a)pyrene	0.2	-
benzo(b)fluoranthene	-	-
benzo(g,h,i)perylene	-	-
benzo(k)fluoranthene	-	-
benzyl alcohol	-	-
carbazole	-	-
chrysene	-	-
dibenzofuran	-	-
di-n-butyl phthalate	-	-
fluoranthene	-	-
fluorene	-	-
indeno(1,2,3-c,d)pyrene	-	-
2-methylnaphthalene	-	-

TABLE 4-2
STATE ARARS AND TBC GUIDANCE - GROUNDWATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

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ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER ^(A) (µG/L)	CLASS I GROUNDWATER ^(B) (µG/L)
naphthalene	-	-
n-nitrosodiphenylamine	-	-
phenanthrene	-	-
pyrene	-	-
Inorganics		
aluminum	50 to 200 ⁽¹⁰⁾	-
antimony	6	-
arsenic	50	50
barium	2,000	1,000
beryllium	4	-
cadmium	5	10
calcium	-	-
chromium (total)	100	50
cobalt	-	-
copper	1,300	1,000
iron	300 ¹⁰	300
lead	15	50
magnesium	-	-
manganese	50 ⁽¹⁰⁾	50
mercury	2	2
nickel	100	-
potassium	-	-
selenium	50	10
silver	100 ¹⁰	50
sodium	20,000 ²	-
vanadium	-	-
zinc	5,000 ¹⁰	5,000
Pesticides/PCBs		
DDT	-	-
DDD	-	-
DDE	-	-
endrin	2 ⁸	0.2

TABLE 4-2
STATE ARARS AND TBC GUIDANCE - GROUNDWATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

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ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER ^(a) (µG/L)	CLASS I GROUNDWATER ^(b) (µG/L)
alpha chlordane	2 ⁸	-
gamma chlordane	2 ⁸	-
heptachlor	0.4	-
PCB 1248	0.5 ⁹	-
PCB 1254	0.5 ⁹	-
PCB 1260	0.5 ⁹	-
Explosives		
cyclotetramethylenetetranitramine (HMX)	-	-
cyclonite (RDX)	-	-
2,4-dinitrotoluene	-	-
2,6-dinitrotoluene	-	-
nitroglycerine	-	-
2,4,6-trinitrotoluene	-	-
Cations/Anions		
chloride	250,000 ¹⁰	-
phosphate	-	-
sulfate	250,000 ¹⁰	250,000
alkalinity	-	-
Other		
nitrate/nitrite (total)	10,000	10,000 ⁸
TPH	-	-

Notes:

- (a) MADEP - Office of Research and Standards; Massachusetts Drinking Water Standards and Guidelines, (310 CMR 22.00) Massachusetts MCLs; Autumn 1994.
- (b) MADEP - Division of Water Pollution Control; Massachusetts Surface Water Quality Standards, (314 CMR 6.06) Minimum GW Quality Criteria - Class I; promulgated December 31, 1986.
- (c) MADEP - Division of Water Pollution Control; Massachusetts Surface Water Quality Standards, (314 CMR 4.05[b]) Class B criteria; promulgated July 20, 1990.
- (d) MADEP; Massachusetts Drinking Water Standards; (310 CMR 22.05[8]) Maximum Microbiological Contaminant Levels; promulgated November 20, 1992.

DWS = Drinking Water Standards
MCLG = Maximum Contaminant Level Goal
MMCL = Massachusetts Maximum Contaminant Level
ORSG = Office of Research and Standards Guideline (Massachusetts)
µg/l = micrograms per liter
- = Standard not established.

- (1) MMCL established for 1,4-dichlorobenzene isomer (more stringent than for 1,2- isomer). Reported values are totals (isomers not distinguished.)
- (2) Value is an Office of Research and Standards guideline.
- (3) Standard indicated is concentration of total trihalomethanes (i.e., the sum of concentrations of chloroform, bromodichloromethane, dibromochloromethane, and bromoform).

- (4) Defers to EPA DWS; see federal MCLs/MCLGs.
- (5) Mean value per any set of samples.
- (6) Numerical standard does not exist. MMCL is based on presence or absence of coliform.
- (7) Nitrate as nitrogen.
- (8) Value reported for chlordane; CAS No. 57749.
- (9) Value reported for PCBs; CAS No. 1336363.
- (10) SMCL = Secondary Maximum Contaminant Levels.

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT* EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC ^c (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL* (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL* (MG/KG)		
Volatile Organics				
acetone	7,800N	200,000N	-	-
benzene	22C	200C	-	-
carbon tetrachloride	4.9C	44C	-	-
chloroform	100C	940C	-	-
ethylbenzene	7,800N	200,000N	-	-
styrene	16,000N	410,000N	-	-
tetrachloroethylene	12C	110C	-	-
toluene	16,000N	410,000N	-	-
1,1,1-trichloroethane	7,000N	180,000N	-	-
1,1,2,2-tetrachloroethane	3.2C	29C	-	-
trichloroethylene	58C	520C	-	-
trichlorofluoromethane	23,000N	610,000N	-	-
xylenes (total)	160,000N	1E+06N	-	-
Semivolatile Organics				
acenaphthene	-	-	-	-
anthracene	23,000N	610,000N	-	-
bis(2-ethylhexyl)phthalate	46C	410C	-	-

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT* EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC ^c (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL* (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL* (MG/KG)		
benzo(a)anthracene	0.88C	7.8C	-	1,317
benzo(a)pyrene	0.088C	0.78C	0.4	1,063
benzo(b)fluoranthene	0.88C	7.8C	-	-
benzo(g,h,i)perylene	-	-	-	-
benzo(k)fluoranthene	8.8C	7.8C	-	-
benzyl alcohol	23,000N	610,000N	-	-
carbazole	32C	290C	-	-
chrysene	88C	780C	0.4	-
dibenzofuran	310N	8200N	-	-
di-n-butyl phthalate	7,800N	200,000N	-	-
fluoranthene	3,100N	82,000N	0.6	1,883
fluorene	3,100N	82,000N	0.035	-
indeno(1,2,3-c,d)pyrene	0.88C	7.8C	-	-
2-methylnaphthalene	-	-	-	0.065
naphthalene	3,100N	82,000N	0.34	-
n-nitrosodiphenylamine	130C	1200C	-	-
phenanthrene	-	-	0.225	139
pyrene	2,300N	61,000N	0.35	1,311

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT* EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC ^c (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL* (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL* (MG/KG)		
total PAHs	-	-	4.0	-
Inorganics				
aluminum	78,000N	1E+06N	-	-
antimony	31N	820N	0.002	-
arsenic	0.37C/23N	3.3C/610N	0.033	-
barium	5,500N	140,000N	-	-
beryllium	0.15C	1.3C	-	-
cadmium	39N	1,000N	0.005	-
calcium	-	-	-	-
chromium	390N ¹	10,000N ¹	0.080	-
cobalt	4,700N	120,000N	-	-
copper	2,900N	76,000N	0.070	-
iron	-	-	-	-
lead	-	-	0.035	-
magnesium	-	-	-	-
manganese	390N	10,000N	-	-
mercury	23N	610N	0.00015	-
nickel	1,600N	41,000N	0.030	-
potassium	-	-	-	-

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT* EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC ^c (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL* (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL* (MG/KG)		
selenium	390N	10,000N	-	-
silver	390N	10,000N	0.001	-
sodium	-	-	-	-
vanadium	550N	14,000N	-	-
zinc	23,000N	610,000N	0.120	-
Pesticides/PCBs				
DDT	1.9C	17C	0.001	0.828
DDD	2.7C	24C	0.002	-
DDE	1.9C	17C	0.002	-
endrin	23N	610N	0.00002	.0332
alpha chlordane	0.49C ³	4.4C ³	0.0005 ³	-
gamma chlordane	0.49C ³	4.4C ³	.0005 ³	-
heptachlor	0.14C	1.3C	-	0.110
PCB 1248	0.083C ⁴	0.74C ⁴	0.05 ⁴	-
PCB 1254	1.6N	41N	0.05 ⁴	19.5
PCB 1260	0.083C ⁴	0.74C ⁴	0.05 ⁴	-
Explosives				
cycloetramethylenetetranitramine (HMX)	-	-	-	-

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT ^b EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC ^c (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL ^a (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL ^a (MG/KG)		
cyclonite (RDX)	-	-	-	-
2,6-dinitrotoluene	78N	2000N	-	-
2,4,6-trinitrotoluene	21C	190C	-	-
nitroglycerine	-	-	-	-
Other				
nitrate/nitrite	130,000N/7,800N	1E+06N/200,000N	-	-
TPH	-	-	-	-

Notes:

- (1) Chromium IV values.
- (2) Dry weight.
- (3) Values reported for chlordanes (CAS # 57-74-9).
- (4) Values reported for total polychlorinated biphenyls (CAS # 1336-36-3).
- (a) U.S. Environmental Protection Agency (USEPA) Region III, January 1995. Memorandum from Roy L. Smith to RBC (Risk-Based Concentration) Table Mailing List, Subject: Risk-Based Concentration Table.
- (b) National Oceanic and Atmospheric Administration (NOAA), March 1990. "The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National States and Trends Program"; NOAA Technical Memorandum NOS OMA52. (Edward R. Long and Lee G. Morgan, authors)
- (c) USEPA, May 1988. "Interim Sediment Quality Criteria Values for Nonpolar Hydrophobic Organic Contaminants".
- (d) USEPA OSWER Directive 193554-02.

mg/kg = milligrams per kilogram
 NOAA = National Oceanic and Atmospheric Administration
 N = Non-carcinogenic effects representing an HQ of 1.0.
 1E+06 = 1,000,000
 SQC = Sediment Quality Criteria
 - = No federal or state guidance criteria or standards exist.
 C = Carcinogenic effects representing a cancer risk of 10⁻⁶.

TABLE 4-4
POTENTIAL LOCATION-SPECIFIC ARARS AT FORT DEVENS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Statutory, Regulatory Basis	Citation	Description
Resource Conservation and Recovery Act	40 CFR Sec. 264.18	Prohibits or restricts siting of hazardous waste management units in certain sensitive areas (100-year floodplain, active seismic area, wetlands).
Migratory Bird Treaty Act of 1972	16 USC Sec. 703-712 50 CFR Parts 10, 20, 21	If migratory birds are present, provides protection of almost all species of native birds in the U.S. from unregulated activities. Unregulated activities can include poisoning at hazardous waste sites.
Fish and Wildlife Conservation Act of 1980	16 USC Sec. 2901 50 CFR Part 83	Requires the submittal of conservation plans outlining provisions to conserve non-game fish and wildlife. Approved conservation plans are enforced by state agencies.
Federal Land Policy and Management Act	13 USC Sec. 1700 et seq.	Establishes requirements concerning utilization of public lands, particularly rights-of-way regulation, land use planning and land acquisition and appropriation of waters on public lands.
Fish and Wildlife Improvement Act	16 USC Sec. 661-666c	Provides for development, protection, rearing, and stocking of all species of wildlife, wildlife resources, and their habitat.
Endangered Species Act	16 USC 1531 et seq. 50 CFR Part 200 50 CFR Part 402	Provides for protection and conservation of various species of fish, wildlife, and plants.
Clean Water Act, Section 404	33 USC 1251 et seq. Sec. 404 40 CFR Part 230	Prohibits discharge of dredged or fill material into wetlands without a permit.

TABLE 4-4
POTENTIAL LOCATION-SPECIFIC ARARS AT FORT DEVENS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Statutory, Regulatory Basis	Citation	Description
Fish and Wildlife Improvement Act	33 CFR 320-330	Provides for management of dredged material; establish requirements for structures affecting navigable waterways; and provides for certain permitting requirements.
Archaeological and Historic Preservation Act	16 USC Sec. 469 40 CFR 6.301(c)	Establishes procedures for preservation of historical and archaeological resources when terrain is altered as a result of a federal or federally licensed construction activity.
National Historic Preservation Act	16 USC Sec. 470 40 CFR Sec. 6.301(b) 36 CFR Part 800	Provides for the protection of historic places.
Historic Sites, Buildings, and Antiquities Act	16 USC Sec. 461-467	Provides for the protection of natural landmarks.
Fish and Wildlife Coordination Act	16 USC 661-667 E	All agencies regulating activities that may have an effect on either fish or wildlife must notify and allow input by agencies overseeing fish and wildlife habitats in the area of the proposed activities.
Coastal Zone Management Act	16 USC 1451 et seq. 15 CFR Parts 923, 928, 932	Provides for the proper maintenance and upkeep of all coastal areas. Protects coastal resources.
Wetlands Protection	310 CMR 10.00-10.99	Establishes State of Massachusetts regulations for protection of coastal and inland wetlands, including compliance with the Massachusetts Environmental Policy Act.

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
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Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Solid Waste Disposal Act	42 USC Sec. 6901-6987	Resource Conservation and Recovery	
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby prohibit open dumps.	Not Applicable
Criteria for Municipal Solid Waste Disposal Facilities	40 CFR Part 258	Establishes minimum federal criteria for design, construction, operation, and permitting of municipal solid waste landfills.	Not Applicable
Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes which are subject to regulation as hazardous waste.	Applicable for defining whether or not hazardous waste is generated
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes standards for generators of hazardous waste	Applicable. If remedial action causes hazardous waste to be generated, these standards will apply
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S.	Applicable. If hazardous waste is transported off-site, these standards will apply

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	Applicable for hazardous waste management activities during remediation
Standards for Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	40 CFR Part 266	Establishes requirements which apply to recyclable materials used in a manner constituting disposal or hazardous waste burned for energy recovery.	If hazardous wastes are recycled on or off-site, these standards are applicable
Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	40 CFR Part 267	Establishes minimum national standards that define acceptable management of hazardous waste land disposal facilities.	Applicable if hazardous waste is present
Land Disposal Restrictions (LDR) Program	40 CFR Part 268	Sets treatment standards for hazardous wastes based on the levels achievable by current technology; sets two-year national variances from the statutory effective dates due to insufficient treatment capacity.	Applicable for hazardous wastes destined for land disposal
Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)	40 CFR Part 280	Provides regulations pertaining to underground storage tanks.	Applicable if there is operation or removal of an UST

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Clean Water Act	33 USC Sec. 1251-1376		
EPA-Administered Permit Programs: The National Pollutant Discharge Elimination System	40 CFR Part 122	Requirements for the discharge of pollutants from any point source into waters of the U.S.	Applicable if remedial action requires outfall discharge
Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR Part 125	Provides discharge criteria, chemical standards, and permit forms for existing industrial operations.	Applicable to remedial actions which cause discharge to waters of the U.S.
Occupational Safety and Health Act of 1970	29 USC Sec. 657 and 667		
Occupational Safety and Health Standards	29 CFR Part 1910	Sets standards for safety in the work environment.	Applicable to all remedial actions
Safety and Health Regulations for Construction	29 CFR Part 1926	Sets standards for safety in the construction work environment.	Applicable to all remedial actions
Safety and Health Standards for Federal Service Contracts	29 CFR Part 1925	States that safety and health standards are applicable to work performed under Federal Service Contracts.	Applicable to all remedial actions
Clean Air Act			

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
National Emissions Standards for Hazardous Air Pollutants	40 CFR Part 61	Establishes emissions standards for hazardous air pollutants that may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating illness.	Applicable to incineration, storage of petroleum liquids; and air stripping activities
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare.	Applicable if there are any air emissions during remediation
Safe Drinking Water Act	40 USC Sec. 300G		
Underground Injection Control Program	40 CFR Part 144	Provides for protection of underground sources of drinking water.	Applicable to underground injection of wastes/contaminated water
Underground Injection Control Program: Criteria and Standards	46 CFR Part 146	Provides technical requirements for UIC programs.	Applicable to underground injection of wastes/contaminated water
Department of Transportation - Hazardous Materials Regulations			
Shipping and Manifesting Requirements for Hazardous Waste	49 CFR Parts 171-179	Provides requirements for packaging, manifesting, and transportation of hazardous waste.	Applicable if offsite shipment of wastes occurs

5.0 AOC 41 REMEDIAL INVESTIGATION

5.1 HISTORY AND SITE CONDITIONS

AOC 41 is approximately 15 acres in size, and is located between Dixie and Jackson Road, New Cranberry Pond, and an eastern portion of the South Post Impact Area (SPIA) (Figure 5-1). The AOC was originally thought to be a small landfill, approximately 100 feet by 100 feet. However, due to the results of the SI and SSI, the RI investigation included an additional 14-acre area around the original landfill material. This area was investigated around the AOC in an attempt to find the source of the site-related groundwater contaminants. The AOC is overgrown with trees, grasses, and swampy vegetation, and no records are available detailing when the site was used or what type of material was disposed of in this area. However, based on air photo review and interviews with installation personnel, it is believed that the AOC was used until the 1950s for disposal of nonexplosive military and household debris. Landfill materials appear to have been associated with these activities, and an old brick-making kiln operated in this area in the 1800s. The AOC was originally thought to contain numerous brake fluid cans. Recent investigations have revealed that these cans are actually an old version of a beer can, as several that had readable labels were discovered (White, 1990). Miscellaneous debris is scattered over a small hill approximately 125 feet north of New Cranberry Pond. The hill slopes down to a low area at the base of waste material. From there, the land rises and then slopes again to New Cranberry Pond (Figure 5-2). The pond, which is a man-made feature created when base personnel installed a road and road culvert (damming up the former stream) at the eastern end of New Cranberry Pond, drains east into the Nashua River (see Figure 2-2). The water level in New Cranberry Pond is controlled by the culvert and a beaver dam that periodically impedes the water flow, which in turn increases the water level in the pond. Installation personnel attempt to keep the culvert clear in an effort to maintain a constant water level in the pond.

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5.2 PREVIOUS SITE INVESTIGATIONS

Two investigations were completed by ABB-ES, under contract to USAEC, prior to the RI. An SI was conducted at AOC 41 in 1992. Results of that investigation are summarized in the Final Site Investigation Report (ABB-ES, 1993b). Based on the findings of the SI, USAEC, USEPA and MADEP determined that additional investigation was necessary to define the nature and distribution of the contaminants detected during the SI. In an attempt to fill these data gaps ABB-ES conducted an SSI at AOC 41 in 1993. Results of that supplemental investigation are presented in the Supplemental Site Investigation Data Package (ABB-ES, 1994a). The following subsections present the data, conclusions, and recommendation for surface soil, subsurface soil, groundwater, surface water, and sediment from these investigations.

5.2.1 Summary of 1992 Site Investigation Activities

The SI at AOC 41 was undertaken in August 1992, in accordance with the Final SI Task Order Work Plan (ABB-ES, 1992b) and in conformance to the provisions of the Fort Devens POP (ABB-ES, 19932a). Table 5-1 summarizes the SI activities.

The field sampling program conducted at AOC 41 (referred to as SA 41 during the SI) consisted of:

- drilling one soil boring for the installation of an apparent upgradient monitoring well;
- collection of six surface soil samples from the waste material's cover soils;
- collection of four downgradient groundwater and soil samples from hand dug sumps;
- collection of two rounds of groundwater samples from the new monitoring well; and
- hydraulic conductivity test;

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- collection of two surface water and sediment sample pairs

These samples were collected to assess adverse impacts to the AOC's media due to the historical use of the AOC, and to assess the threat to human health and/or the environment. Figure 5-2 presents the locations of the SI explorations. The areal extent of the dump was flagged based on visual observations and surveyed for vertical and horizontal control.

A unexploded ordinance (UXO) survey was completed at all the exploration locations prior to any intrusive activities. A UXO subcontractor used surficial and down-hole techniques to clear all explorations for the potential of UXO.

One boring, 41M-92-01X, was drilled to the water table in an apparent upgradient position (north) of the waste material (see Figure 5-2). Soil samples were collected continuously to assess the geologic conditions at this location. One soil sample was collected from the water table for analysis of TOC. Three soil samples were obtained from this boring for grain size analysis to verify field classifications of soil.

One 4-inch inside diameter (ID) polyvinyl chloride (PVC) monitoring well was installed in boring 41M-92-01X. A 10-foot long well screen was installed across the water table (approximately 7 feet below and 3 feet above the water table). Aquifer hydraulic conductivities of the soil at the water table were evaluated by performing two rising-head hydraulic conductivity tests in the well after development and the first and second rounds (Round One and Round Two) of groundwater sampling.

Two rounds of groundwater samples were collected from 41M-92-01X. The first round was collected in September 1992 and the second round in January 1993. As part of the Round One sampling, four downgradient groundwater samples were collected from the hand dug sumps south of the waste material (see Figure 5-2). The groundwater samples collected during Round One were not filtered prior to inorganic analysis. The second round of groundwater sampling included the collection of an unfiltered and filtered groundwater sample from 41M-92-01X for inorganic analysis. Groundwater samples were not collected from the sumps during Round Two. The filtered inorganic sample from Round Two was collected and analyzed in an attempt to determine if the inorganics detected

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SECTION 5

in the sample were primarily dissolved or associated with suspended solids. The groundwater samples from both rounds were submitted to the off-site laboratory for analysis of PAL VOCs, SVOCs, inorganics, TPHC, selected anions and cations, pesticides/PCBs, and explosives. Groundwater samples collected from the sumps and the Round Two sample from 41M-92-01X were also analyzed for TSS (Table 5-2).

Six surface soil samples (41S-92-01X through 41S-92-06X) were collected from the soil cover on the fill area to assess whether the surface of the waste poses a risk to human or ecological receptors. In addition to these soil samples, four soil samples were collected from the sumps dug between the landfill and New Cranberry Pond. These samples were obtained from 1-foot to 2-feet below ground surface (bgs) and were considered as surface soil (see Figure 5-2). The surface soil samples collected from the soil cover on the landfill, were taken from areas where apparent visible contamination was observed. The surface soil samples were submitted for off-site laboratory analysis consisting of PAL VOCs, SVOCs, inorganics, TPHC, pesticides/PCBs, explosives, TOC, and/or grain size (see Table 5-2).

Two surface water and sediment sample pairs (41D-92-01X and 41D-92-02X) were collected from the northern shore of New Cranberry Pond (see Figure 5-2). These samples were used to assess whether the historic use of the AOC has impacted surface water or sediment quality, and, therefore, poses a threat to human or ecological receptors. Both of the surface water samples were submitted for off-site laboratory analysis of PAL VOCs, SVOCs, inorganics, TPHC, pesticide/PCBs, explosives, and water quality parameters. Sediment samples were submitted for laboratory analysis of PAL VOCs, SVOCs, inorganics, TPHC, pesticide/PCBs, explosives, TOC, and grain size (see Table 5-2).

All SI sampling locations were surveyed.

5.2.2 Summary of Site Investigation Results and Observations

The soil types encountered in boring 41M-92-01X included clayey silt from 4 to 36 feet bgs. Grain size testing of two soil samples showed that the clayey silt makes up more than 97 percent of the soil. This material was mapped by Koteff (1966) as Ayer Stage lake deposits, and it is a probable stratigraphic equivalent of

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the lake-bottom deposits mined by New England Brick Co. which operated the former brick kiln located on-site. A detailed discussion of the geologic setting at AOC 41 is presented in Section 6.0 of this report. The boring log for 41M-92-01X is provided in Appendix A, and grain size results are provided in Appendix B.

Monitoring well 41M-92-01X was installed as part of this investigation at a location presumed to be upgradient of the landfill. The monitoring well was screened across the water table to monitor for floating contaminants and allow for seasonal fluctuations in the groundwater table. Monitoring well completion details are provided in Appendix C.

Aquifer hydraulic conductivities for the soil at the water table were determined by conducting rising head tests in monitoring well 41M-92-01X and using two different computational methods. The geometric mean of those tests was 1.73×10^{-5} cm/sec, consistent with the clayey nature of the soil. The results of these tests are provided in Appendix D.

The closest major surface water body near AOC 41 is New Cranberry Pond which drains to the Nashua River. The water of the Nashua River has been assigned to Class B. Class B surface water is "designated for the uses of protection and propagation of fish, other aquatic life and wildlife, and for primary and secondary contact recreation" (314 CMR 4.03).

Groundwater in the surficial aquifer at the facility has been assigned to Class I under Commonwealth of Massachusetts regulations. Class I consists of groundwaters that are "found in the saturated zone of unconsolidated deposits or consolidated rock and bedrock and are designated as a source of potable water supply" (314 CMR 6.03).

A detailed discussion of the hydrogeologic conditions at AOC 41 are presented in Section 6.0 of this report.

The objective of the SI sampling at AOC 41 was to investigate the presence or absence of environmental contamination caused by the historical use of the landfill, and if found, assess the vertical and horizontal distribution of contaminants, and recommend further actions. Samples of soil and groundwater were collected to characterize local impacts from the waste material.

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Groundwater and surface soil samples were collected for off-site laboratory analysis to assess downgradient impacts.

5.2.2.1 Soil. Six surface soil samples were collected from visibly stained soils within the boundaries of the observed dumping area (see Figure 5-2). Additionally, four surface soil samples were collected from the four sumps that were completed between the landfill and the pond.

No VOCs were detected in any of the 10 surface soil samples. SVOCs, in the form of polynuclear aromatic hydrocarbons (PAHs), were detected in all six soil samples collected from the waste material. Pesticides and TPHC were also detected in several surface soil samples. No explosive compounds were detected in any of these surface soil samples (Table 5-3).

Inorganic analytes at concentrations greater than the established Fort Devens background concentrations were detected in all six of the surface soil samples collected from the waste material (Table 5-4).

Soil samples collected from the sumps were initially collected as sediment samples, but were used as surface soil samples in the SI data assessments. The results have been used to determine the soil quality downslope of the waste material. Acetone was the only VOC detected in these samples (a common laboratory contaminant). Sodium and beryllium (in one sample) were the only inorganic analytes detected above the established Fort Devens background concentrations. PAHs were detected in the soil sample collected from 41D-92-03X, and concentrations of pesticide residues were detected in samples collected from 41D-92-03X, 41D-92-05X, and 41D-92-06X. No distinct lateral distribution of these contaminants is evident from the data collected (see Tables 5-3 and 5-4).

5.2.2.2 Surface Water and Sediment. Two surface water/sediment samples were collected from the northern edge of New Cranberry Pond to assess whether the landfill had impacted surface water and/or sediment quality (see Figure 5-2). Toluene was detected in one surface water sample (41D-92-01X) at 0.56 $\mu\text{g/L}$ and was the only organic compound detected in either surface water sample. Results of the sediment analyses indicated the presence of several pesticide compounds

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and four inorganic analytes (barium, copper, sodium, zinc) above typical soil inorganic background concentrations at Fort Devens (Tables 5-5 and 5-6).

5.2.2.3 Groundwater. Two rounds of groundwater samples were collected from 41M-92-01X, and one round (Round One) of groundwater samples were collected from the sumps dug in the low area between the landfill material and New Cranberry Pond. Chlorinated solvents (TCE and 1,1,2,2-TCA) were detected in the Round One groundwater sample collected from 41M-92-01X. No SVOCs, pesticides, PCBs or TPHC were detected in the Round One sample. The groundwater sample from Round One also contained detectable concentrations of nitrate/nitrite and one explosive degradation compound (2,4,6-trinitrotoluene). The results of the Round Two analyses confirmed the presence of chlorinated solvents detected in the Round One sample. One pesticide (endrin) was also detected in the Round Two sample. The explosive compound was not detected in the Round Two analysis, and nitrate/nitrite was detected at a significantly lower value. No SVOCs or TPHC were detected in the Round Two groundwater sample (Table 5-7).

All inorganic analytes detected in the Round One unfiltered groundwater sample were above the established Fort Devens background concentrations. A filtered groundwater sample was not collected for inorganic analysis during Round One. Inorganic results from the Round One and Two unfiltered samples showed that each of the PAL inorganic analytes were detected above its Fort Devens background except for antimony, beryllium, mercury, and silver. The results of the filtered inorganic sample showed only potassium to be above the Fort Devens background (see Table 5-7).

No organic compounds were detected in any of the sump samples collected during Round One. Due to high TSS concentrations, the resulting inorganic analyte concentrations in these unfiltered water samples were also above the established Fort Devens background groundwater concentrations. Groundwater samples were not collected from these sumps during the Round Two groundwater sampling event (see Table 5-7). A complete discussion of the groundwater data is presented in Section 7.0 of this report.

5.2.2.4 Site Investigation Conclusions and Recommendations. Based on the off-site laboratory results and the findings of the SI Preliminary Risk Evaluation

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(PRE) from the SI sampling at AOC 41, there appeared to be a potential risk to human receptors indicated in a residential exposure scenario associated with PAHs and inorganics in the surface soil samples collected from the waste material, and due to VOCs and inorganics in groundwater. Based on these findings it was determined that SSI activities at AOC 41 were required to determine the source and distribution of the VOC groundwater contamination, and assess the distribution of the contaminants detected in the waste material cover soils. Collection of this additional data would also allow for a more comprehensive risk evaluation.

5.2.3 Summary of 1993 Supplemental Site Investigation Activities

The SSI at AOC 41 was undertaken in August 1993, in accordance with the Final SSI Task Order Work Plan (ABB-ES, 1993d) and in conformance to the provisions of the Fort Devens POP (ABB-ES, 1993e). Table 5-1 summarizes the scope of the SSI at AOC 41.

The SSI field program consisted of:

- completion of a UXO survey prior to intrusive explorations and geophysical surveys in the Impact Area;
- completion of magnetometer and terrain conductivity geophysical surveys near the waste material;
- drilling of five soil borings for the collection of soil samples and the installation of monitoring wells;
- collection of three sediment samples from the low area at the base of the waste material;
- collection of two surface water and sediment samples from the northern shore of New Cranberry Pond;
- hydraulic conductivity tests; and

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- collection of two rounds of groundwater samples from the five new wells and the existing monitoring well.

A UXO survey was completed to clear all exploration locations of potential unexploded ordinance prior to all surficial and intrusive activities and prior to the geophysical survey.

A surficial geophysical survey was conducted in the area directly north, east and west of waste material, to determine if a source area of the chlorinated solvent contaminants, detected during the SI, was near by. The geophysical survey consisted of a magnetometer survey and terrain conductivity survey. The survey area is shown in Figure 5-3.

Five soil borings (41M-93-02A and B, 41M-93-03X, 41M-93-04X, and 41M-93-05X) were drilled upgradient and downgradient of the waste material for the installation of groundwater monitoring wells (see Figure 5-3). Three soil samples were collected from the monitoring well boring at 41M-93-02B and one soil sample was collected from 41M-93-03X. These samples were submitted for off-site laboratory analysis for PAL VOCs, SVOCs, inorganics, explosives, pesticides/PCBs, and TOC. One soil sample from the screened interval of each of the monitoring well borings (41M-93-04X and 41M-93-05X) was analyzed for TOC only (see Table 5-2). Grain-size distribution tests were performed on selected soil reference samples. Soil boring information is summarized in Table 5-8.

To further define the distribution of contaminants detected in the low area at the base of the waste material, three sediment samples (41D-93-07X through 41D-93-09X) were collected. No surface water samples were collected from these sampling points due to insufficient surface water volumes at the time of sampling. Two surface water and sediment pairs (41D-93-10X and 41D-93-11X) were collected from the northern side of New Cranberry Pond (see Figure 5-3). The surface water samples were analyzed for PAL VOCs, SVOCs, inorganics, explosives, pesticides/PCBs, and water quality parameters. All of the sediment samples collected from AOC 41 during the SSI were analyzed for PAL VOCs, SVOCs, inorganics, explosives, pesticides/PCBs, grain size, and TOC (see Table 5-2).

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Five groundwater monitoring wells (41M-93-02A, 41M-93-02B, 41M-93-03X, 41M-93-04X, and 41M-93-05X) were installed in the soil borings mentioned above. Monitoring well 41M-93-03X was installed in an apparent upgradient location. Because the geophysical surveys did not identify a potential upgradient source, the monitoring well pair 41M-93-02A and B were installed in close proximity (approximately 60 feet north) to the existing monitoring well 41M-92-01X to determine if the solvent contamination detected in the groundwater, was a localized condition. Monitoring wells 41M-93-04X and 41M-93-05X were installed between the waste material and New Cranberry Pond, interpreted as an apparent downgradient location at the time of the SSI (see Figure 5-3).

Two rounds of groundwater samples were collected from the new and existing monitoring well. Round Three groundwater samples were collected from the five newly installed monitoring wells and the existing monitoring well in October 1993, and Round Four samples were collected from the same monitoring wells in January 1994. Both rounds of groundwater samples were analyzed for PAL VOCs, SVOCs, inorganics (both filtered and unfiltered), explosives, pesticides/PCBs, and TSS.

All SSI sampling points were surveyed.

5.2.4 Summary of Supplemental Site Investigation Field Investigation Results and Observations

The results of the two geophysical surveys did not indicate any unusual magnetic or ferrous metal anomalies within the survey grid. These results indicate that there was no apparent source area for the detected groundwater contamination within the SSI geophysical grid (additional magnetometer and terrain conductivity surveys were performed during the RI). To allow for a more thorough presentation of the data, the SSI geophysical data will be presented with the geophysical data collected during the RI in Subsection 5.4.2 and Appendix E of this report.

Soil encountered in the monitoring well boring at 41M-93-02B (north of the waste material) was a clayey silt. This material was mapped by Koteff (1966) as Ayer Stage lake deposits. This soil is very similar to the soils encountered in

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41M-92-01X drilled during the SI. The soils encountered in 41M-93-03X (located on the access road north of the waste material) were primarily sand overlaying clayey silt. The boring logs for these locations are presented in Appendix A. A detailed discussion of the geologic setting at AOC 41 is presented in Section 6.0 of this report.

Because of the lack of geophysical anomalies, USAEC decided to install a monitoring well pair (41M-93-02A and 41M-93-02B) at a location that was designed to determine if the contaminants detected in the existing monitoring well (41M-92-01X) were a localized occurrence or more wide-spread. Monitoring well 41M-93-03X was installed to monitor apparent upgradient groundwater quality. (Groundwater flow directions could not be determined during the SI because only one well was installed; therefore, groundwater flow direction could only be estimated based upon topography). Two well points (41M-93-04X and 41M-93-05X) were installed between the waste material and New Cranberry Pond to monitor apparent downgradient groundwater quality and supplement the SI sump data (see Figure 5-2). Well construction diagrams for these monitoring wells are presented in Appendix C.

The SSI monitoring wells were developed, and two hydraulic conductivity tests (slug tests) were performed in each monitoring well after Round Three groundwater sampling was completed. Results of the hydraulic conductivity test indicated hydraulic conductivity ranged from 4.0×10^{-2} cm/sec at 41M-93-04X to 1.6×10^{-5} cm/sec at 41M-93-03X.

Groundwater and surface water (New Cranberry Pond) elevations measured after the SSI monitoring wells had been installed, indicated that the surface water from New Cranberry Pond was recharging local groundwater. A detailed discussion of the hydrogeologic conditions at AOC 41 are presented in Section 6.0 of this report. Hydraulic conductivity test plots are presented in Appendix D.

The objective of the SSI sampling and chemical analysis at AOC 41 was to further define the nature and distribution of the contaminants previously detected in surface water and sediment, and groundwater. Samples were collected to further assess impacts on surface water and sediment quality that could have affected ecological receptors. Groundwater samples were collected to better assess the

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potential human health risks associated with contaminants detected in the groundwater during the SI.

5.2.4.1 Subsurface Soil. Three subsurface soil samples were collected from 41M-93-02B and 41M-93-03X and submitted for off-site laboratory analysis. No VOCs, explosives, or pesticide/PCBs were detected in the subsurface soil samples collected during the SSI. Several inorganic analytes were detected above their established Fort Devens background concentration (Table 5-9 and 5-10).

5.2.4.2 Surface Water/Sediment. Three sediment samples (41D-93-07X through 41D-93-09X) were collected from the wet area at the base of the waste material, and two surface water and sediment sample pairs (41D-93-10X and 41D-93-11X) were collected from the north shore of New Cranberry Pond. Sediment sampling locations 41D-93-07X through 41D-93-09X were designed to assess the sediment quality downslope of the waste material.

PAHs were detected in the sediment samples collected from the wet area at the base of the waste material. Similar PAHs were detected in surface soil samples collected from the top of the waste material during the SI. These compounds may be present at these locations because of overland transport of surface soil from the top of the waste material to the sediments at the base of the waste material via surface water runoff (see Table 5-6).

Only one organic compound (1,2-dichloroethane [1,2-DCA]) was detected in the surface water sample collected from New Cranberry Pond, (41D-93-10X and 41D-93-11X) (see Table 5-5).

One chlorinated solvent (1,2-DCA) was detected in the SSI sampler blank. This compound was not reported above the CRL in any of the laboratory blanks. The contract laboratory, ESE, indicated that a deuterated form of 1,2-DCA is used as a surrogate for the volatile organic analysis method. The surrogate is not always 100 percent pure, often containing low concentrations of the undeuterated form of 1,2-DCA. Occasionally the concentrations of incidental 1,2-DCA are high enough to exceed the CRL. The surrogate spike would appear to be a possible means of introduction of this compound into the surface water samples. Also, because of 1,2-DCA's volatile nature, it is unlikely that it would be found in surface water. Based on this information, it is likely that the 1,2-DCA was introduced into the

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surface water sample at the off-site laboratory. Additionally, Subsection 6.3 of this report presents information that contaminants up-slope in groundwater (including 1,2-DCA) are not likely to discharge into New Cranberry Pond. Therefore, the 1,2-DCA detected in surface water is not considered an AOC-derived contaminant. No notable inorganic analytes were detected in either surface water sample.

Sediment samples collected from New Cranberry Pond indicate the presence of low levels of two pesticides and one PCB. The PRE completed for the SSI indicates that these low levels averaged across all sediment samples collected from New Cranberry Pond would be unlikely potential risk sources (see Table 5-6).

5.2.4.3 Groundwater. Two rounds of groundwater samples (Rounds Three and Four) were collected from the existing and newly-installed monitoring wells during the SSI. No SVOCs, explosives, or pesticides/PCBs were detected in either Round Three or Four. Several chlorinated solvents were detected in the groundwater samples collected from the existing and newly installed monitoring wells during Round Three. 1,2-Dichloroethene (1,2-DCE) was detected in 41M-93-02B, and 1,1,2,2-TCA was detected in 41M-92-01X and in 41M-93-02B. This compound was also detected in Round One and Round Two in 41M-93-01X. PCE was detected in 41M-92-01X. TCE was detected in 41M-92-01X and in 41M-93-02B. This compound was also detected at 41M-92-01X in Round One and Round Two samples, and methylethyl ketone was detected in 41M-93-02A (see Table 5-7).

Several inorganic analytes were detected above their Fort Devens background concentrations in the unfiltered groundwater samples. However, only arsenic, antimony, and manganese were detected above their background concentrations in Round Three filtered samples (see Table 5-7).

5.2.5 Supplemental Site Investigation Conclusions and Recommendations

The revised SSI PRE concluded that six analytes (4,4'-DDD, 4,4'-DDE, heptachlor, arsenic, lead, and zinc) in sediment samples collected from New Cranberry Pond, were detected at levels in excess of ecological benchmark values. The maximum concentrations of these analytes were all detected in one sediment

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sample (41D-92-01X, collected during the SI). The SSI PRE further states that the average concentrations of all three inorganic analytes were at or near the benchmark value, indicating that it is highly unlikely that arsenic, lead, or zinc pose a risk to aquatic receptors at New Cranberry Pond. It is also unlikely that the pesticide concentrations detected in the same sediment samples posed a risk to ecological receptors. This interpretation, coupled with the physical site condition which showed that the overland transport of any waste material contaminant to New Cranberry Pond was not possible (due to topography), and that surface water appeared to be recharging groundwater; indicated that additional investigation of New Cranberry Pond was not needed.

Based on the off-site laboratory results from the SSI groundwater sampling at AOC 41, it was determined that RI activities at AOC 41 were required to determine the source and distribution of the VOC groundwater contamination, and better define the groundwater flow direction and hydrogeologic conditions. The collection of this additional data would also allow for a more comprehensive human health risk evaluation.

5.3 REMEDIAL INVESTIGATION PROGRAM

5.3.1 Technical Objectives

The following subsections present the technical objectives of the investigation techniques, field analytical, and off-site laboratory analytical programs for the AOC 41 RI.

5.3.1.1 Soil Borings. The technical objective of the soil boring program was to obtain representative soil samples for conducting field (rigside) screening, off-site laboratory analyses, and grain size distribution. In addition, borings were intended to yield data to further define VOC contaminant distribution and the geologic setting at AOC 41. This includes location of the site within the regional stratigraphic setting and identification of fine-grained soil layers.

5.3.1.2 Screened Auger Borings. The technical objective of the screened auger program was to collect groundwater samples for field analysis. The results were

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used to define the horizontal and vertical distribution of VOC groundwater contaminants.

5.3.1.3 Test Pitting. The technical objective of the test pitting program was to collect soil samples from potential groundwater contaminant source areas and from below the waste material. Samples were collected for PAL analytes and leachability characteristics of the waste samples. The excavations were also intended to give a possible delineation of the vertical extent of debris materials.

5.3.1.4 Monitoring Wells. The technical objective of the monitoring well program was to install monitoring wells in geologic strata to better characterize the local groundwater flow system and contaminant distribution. This included collecting water level data to establish flow directions, and vertical and horizontal gradients, and estimating the hydraulic conductivity of the geologic strata.

5.3.1.5 Field Laboratory Analysis. The technical objective of the field analytical program was to quickly generate USEPA Level II analytical data for previously identified site-related compounds (specifically TCE) allowing for preliminary identification of distribution. This information enabled more accurate placement of groundwater monitoring wells. In addition, field analytical data were used to support the results and findings of the contaminant assessment. Field analytical techniques employed as part of this RI are discussed in detail in Subsection 3.1 of this report. Results of the field analyses are discussed in detail in Section 7.0 of this report.

5.3.1.6 Off-Site Laboratory Analytical Sampling. The technical objective of the analytical sampling program was to enhance the analytical database for subsurface soil and groundwater at AOC 41. This database was used as the foundation for the contamination assessment and fate and transport discussion. Off-site laboratory analytical methods employed as part of this RI are discussed in detail in Subsection 3.2 of this report. Results of the analytical data are discussed in detail in Section 7.0 of this report.

5.3.2 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative or quantitative statements developed by the data user to specify the quality of data needed from a particular

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activity to support specific decisions. DQOs are the starting point in the design of the remedial investigation. The DQO development process matches sampling and analytical capabilities to the data targeted for specific uses and ensures that the quality of the data does not underestimate project requirements. The procedures of the QA objectives presented in Section 3.0 of Volume I of the Fort Devens POP were followed during the RI field program at AOC 41 (ABB-ES, 1993e). This subsection includes a general scope of work, DQOs and the QA/QC approach.

Analyses were conducted on samples collected from AOC 41 to evaluate the nature and distribution of the contaminants detected in the previous investigations. On-site field analysis conformed with the guidelines presented in Subsection 4.6 of Volume I of the Fort Devens POP. Off-site laboratory analytical procedures are presented Section 7.0 of Volume I of the POP, and the Laboratory QA Plan and the USAEC Certified Analytical Methods procedures are presented in Appendices B and C, respectively, in Volume II of the Fort Devens POP (ABB-ES, 1993e).

USEPA has identified five general levels of analytical data quality as being potentially applicable to field investigations conducted at potential hazardous waste sites under CERCLA. These levels are summarized as follows:

- Level I - Field Screening. This level is characterized by the use of portable instruments that can provide real time data to assist in optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.
- Level II - Field Analysis. This level is characterized by the on-site use of portable analytical instruments and mobile laboratories which can render qualitative and quantitative data.
- Level III - Laboratory analysis using methods other than Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is used primarily to support engineering studies using standard USEPA-approved procedures. Some procedures may be

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equivalent to the USEPA RAS, without the CLP requirements for documentation.

- Level IV - CLP RAS. This level is characterized by rigorous QA/QC protocols and documentation, providing qualitative and quantitative analytical data.
- Level V - Non-standard methods. This level includes analyses that may require modification and/or development. CLP Special Analytical Services are considered Level V.

For AOC 41 RI efforts, field measurements such as pH, temperature, conductivity, and readings from a PID and O₂/Explosimeter constituted Level I field analytical data. Field GC analysis constituted Level II field analytical data. Analyses of soil and groundwater for organics, inorganics, TOC, TPHC, water quality parameters, pesticides and PCBs, and explosives were considered approximately equivalent to USEPA analytical support Level III. The sampling approaches and analytical procedures described in the ABB-ES Fort Devens POP have been selected to meet Level III data quality.

DQOs were established to support the level of detail required for RI activities. Data generated during field and off-site laboratory tasks were used to characterize AOC 41 conditions and to perform baseline risk assessments.

DQOs and QC for field measurements and laboratory analyses conform to USAEC and USEPA requirements (as specified in the USAEC Quality Assurance Manual, 1990 and Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, 1988).

USAEC requirements and analytical processes are discussed in Section 3.0 of this report. They focus on the use of laboratory control spikes in associated data lots to measure the performance of the laboratory in the use of USAEC methods. Many of the USAEC methods are identical to standard USEPA methods. The performance demonstration process, required by laboratories performing USAEC work, is discussed in Subsection 3.2.1. The data review and evaluation process are described in Subsection 3.2.3.

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Off-site laboratory data were evaluated for precision, accuracy, representativeness, completeness and comparability (PARCC) to meet USEPA Level III requirements. This was accomplished through the collection of field quality control blanks such as field blanks, trip blanks, and equipment rinsates, and through the evaluation of laboratory blanks such as method blanks. The specific purpose of collecting each of these is discussed in Section 3.0 of this report. Laboratory control spikes are run in the certification process to generate control charts that help to establish control limits that are used to ensure accuracy of the results. This process is also described in the text of the report in Section 3.0. Matrix spike and duplicate samples were also analyzed to meet PARCC data quality objectives. These are separated by year for AOCs 43G, 43J, and 41 collectively, and are presented in Appendix H.

The precision of the data is a measurement of the ability to reproduce a value under certain conditions. It is a quantitative measurement based on the differences of two values. Precision was evaluated using the RPD of MS/MSD sample pairs and field duplicate sample pairs. Evaluations of the precision of the data are found in Appendix H.

Accuracy measurements identify the performance of a measurement system based on tests with known values. The off-site laboratory, sampling, and media effects on accuracy were assessed by reviewing the percent recoveries of spiked analytes for MS/MSDs, off-site laboratory control samples, and surrogate compounds.

Representativeness refers to the extent to which a measurement accurately and precisely represents a given population within the accepted variation of laboratory and sampling measurements. Collection techniques that obtained samples characteristic of the matrix and location being evaluated were chosen. Historic information was used to identify sample locations. Representativeness was also evaluated using method blanks and field QC sample data. By evaluating method blank and field QC samples, false positive results should be identified. Representativeness was also measured by evaluating field duplicate pair precision.

Completeness refers to the percentage of usable, valid values obtained through data evaluation. Completeness was determined by the success rate in meeting holding time criteria and acceptance of sample lots by USAEC.

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Comparability is a qualitative assessment describing the confidence with which one data set may be compared with another. Comparability was assured using standard operating procedures for sampling, and by reporting analytical results in standard units.

5.4 SUMMARY OF 1994 REMEDIAL INVESTIGATION PROGRAM

The RI was conducted in conformance with the Revised Final RI Task Order Work Plans for AOC 41, AOC 43G, and AOC 43J (ABB-ES, 1994b) and the Final Project Operations Plan (ABB-ES, 1993e).

The RI program for AOC 41 consisted of:

- installation of a PVC standpipe on the northern shore of New Cranberry Pond to monitor the surface water elevation in the pond;
- surficial and downhole UXO clearance;
- geophysical surveys (terrain conductivity and magnetometer) over approximately 12 acres to identify potential groundwater contaminant source areas;
- drilling 23 screened auger borings;
- field analysis of groundwater samples collected from the screened auger borings using a field GC;
- excavation of nine test pits and subsurface soil sampling;
- drilling 13 soil borings and subsurface soil sampling;
- installing 13 monitoring wells in the soil borings;
- well development of all newly installed monitoring wells;

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- two rounds of groundwater sampling for all new and existing monitoring wells (19 groundwater samples per round);
- off-site laboratory analysis of environmental samples;
- in situ aquifer conductivity testing in each newly installed monitoring well;
- horizontal and vertical survey of explorations and measurement points;
- TerraProbeSM exploration program for soil vapor and soil screening (16 points total); and
- long-term monitoring of water levels in New Cranberry Pond and two monitoring wells.

ABB-ES established a project field office in Building 201 on Fort Devens' Main Post. The field office was used for equipment storage and maintenance, sample management, shipping and receiving, staff meetings, and communications. A telephone was maintained in the field office; each field crew was issued a hand-held cellular phone. An equipment decontamination pad was constructed at AOC 41. ABB-ES and subcontractor staff were briefed about the nature of AOC 41, health and safety information, Fort Devens traffic regulations, and key technical requirements.

ABB-ES began implementation of the AOC 41 field program in September 1994, with equipment mobilization, subcontractor mobilization, and UXO and geophysical surveys.

The subcontractors used by ABB-ES in conducting the RI program were as follows:

- D.L. Maher, North Reading, MA - Drilling and monitoring well installation.
- ESE, Gainesville, FL - Chemical analysis of environmental samples.

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- UXB International, Inc., Chantilly, VA - Clearance of unexploded ordnance.
- Martinage Engineering Assoc., Inc., Reading, MA - Surveying of site explorations.

All field activities were conducted in accordance with the Fort Devens POP and USAEC's Geotechnical Guidelines (USAEC, 1987). The following subsections describe the proposed field activities for the RI/FS at AOC 41.

5.4.1 Unexploded Ordnance Clearing Survey

A UXO clearing survey was conducted to identify the location of potential UXO located on the surface or in subsurface soils at AOC 41. The procedures for the UXO survey is presented in Subsection 4.4.2 of Volume I of the Fort Devens POP (ABB-ES, 1993e).

A surficial UXO clearance survey was conducted by a UXO subcontractor prior to initiation of surficial geophysical surveys. The UXO subcontractor cleared the surface and cut shrubs and/or trees along the geophysical grid across approximately 8 to 12 acres (Figure 5-4). Several fired ordnance cartridges were found during surface clearance, however, no UXO was detected that warranted disposal.

The same UXO subcontractor was employed to conduct subsurface UXO boring clearance during all intrusive investigatory activities (i.e., drilling and test pitting). Procedures for this portion of the field program are presented in Subsection 4.4.2 of Volume I of the Fort Devens POP (ABB-ES, 1993c). The UXO subcontractor encountered anomalies in the subsurface during the clearance. These anomalies were not investigated or removed, did not hamper field activities, and do not appear to pose a threat to future site activities.

5.4.2 Surficial Geophysical Survey

A surficial geophysical survey was conducted in an attempt to locate the potential source area(s) of the VOC contamination detected in the groundwater samples during the SI and SSI. Magnetometer and terrain conductivity surveys were

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conducted along a 20-foot grid with 10-foot spacings between each grid line. The grid covered approximately 8 acres and was tied into the grid completed during the SSI (see Figure 5-4). A discussion of geophysical results are presented in Subsection 6.2.3 of this document. Surficial geophysical survey procedures are presented in Subsection 4.4.3 of Volume I of the Fort Devens POP (ABB-ES, 1993e). A complete summary of the geophysical data is presented in Appendix E.

5.4.3 Screened Auger Borings

Twenty-three screened auger borings (SA4101 through SA4123) were completed at AOC 41 (see Figure 5-3). Groundwater samples were collected at the water table at 22 of the 23 locations. At location SA4123, a total of five groundwater samples were collected at 5-foot intervals from 50 to 70 feet bgs (Table 5-11). Groundwater samples were also collected from existing monitoring wells for field analysis to compare field analytical results to historical results and supplement the screened auger program. Groundwater samples were collected after only one well volume had been removed. Groundwater sampling procedures are outlined in Subsection 4.5.2.2 of Volume I of the Fort Devens POP (ABB-ES, 1993e).

Groundwater samples were analyzed for vinyl chloride, 1,2-DCE, benzene, TCE, toluene, PCE, ethylbenzene, xylenes, 1,1,2,2-TCA, and 1,2-dichlorobenzene. Results of the field analysis were used to determine the vertical and horizontal distribution of the VOC contamination previously detected in the groundwater at AOC 41. Procedures for the screened auger sampling are presented in Subsection 4.4.6.2 of Volume I of the Fort Devens POP (ABB-ES, 1995). Field analytical procedures are presented in Subsection 4.6 of Volume I of the POP (ABB-ES, 1993c) and Subsection 3.1 of this report. Screened auger boring logs are presented in Appendix A. Sample results are discussed in Section 7.0 of this report.

5.4.4 Test Pitting

A total of nine test pits (41E-94-01X through 41E-94-09X) were excavated in and around the landfill waste material, geophysical anomalies and monitoring wells 41M-93-03X and 41M-94-03B (see Figure 5-4). A tire-mounted backhoe was used to excavate each of the pits. ABB-ES's UXO subcontractor operated the backhoe and cleared the surface and subsurface for UXO. Up to three soil samples were

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collected from each test pit. Samples were submitted for laboratory analysis consisting of PAL VOCs, SVOCs, inorganics, TPHC, and TOC. Samples collected from 41E-94-01X through 41E-94-03X were also analyzed for Toxicity Characteristic Leaching Procedure. Sample results are discussed in Subsection 7.2.1.2 of this report. Test pitting procedures are outlined in Subsection 4.4.4 of Volume I of the Fort Devens POP (ABB-ES, 1993e).

During the test pitting, the ABB-ES geologist described activities and observations in test pit logs. Test pit logs are presented in Appendix A and summarized in Table 5-12.

5.4.5 Soil Borings and Soil Sampling

A total of 13 soil borings (41M-94-02C, 41M-94-03B, 41M-94-06X through 41M-94-14X, including 41M-94-08B and 41M-94-09B) were completed during the RI for soil classification, field screening (rig side) and monitoring well installation (see Figure 5-4). One soil sample from each boring was submitted for off-site laboratory analysis of TOC and grain size distribution. All of the soil borings were drilled using 6.5-inch ID hollow-stem augers (HSAs). The boring logs are presented in Appendix A and summarized in Table 5-8. Sample results are discussed in Section 7.0 of this report. Soil boring procedures are presented in Subsection 4.4.6.1 of Volume I of the Fort Devens POP (ABB-ES, 1993e).

Drilling of soil borings at AOC 41 proceeded as follows:

- The surface of the working area around each boring locations was cleared for UXO by ABB-ES's UXO subcontractor.
- Sampling and drilling was performed under direct supervision of an ABB-ES geologist or hydrogeologist.

Subsurface soil samples were collected with split-spoon samplers advanced using the standard penetration test technique. Most samples were collected with 3-inch ID samplers to obtain greater soil volumes.

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Soil samples were screened in the field (rigside) using a PID. Soil samples from each boring were used for geologic description and then placed in reference jars for storage.

5.4.6 TerraProbeSM Sampling

Between March 30, 1995 and April 4, 1995 (not continuous), 16 TerraProbeSM points were completed for the collection of 22 soil vapor and 30 soil samples. All points were completed near monitoring well pair 41M-93-03X and 41M-94-03B. A combination of media were collected from some of the points. A summary of the explorations is presented in Table 5-13 and the locations of the explorations are presented in Figure 5-5. The TerraProbeSM sampling procedures are presented in Subsection 4.5.1.3 of the Fort Devens POP (ABB-ES, 1993e).

All samples (regardless of media) were analyzed in the field for TCE and trans and cis-1,2-DCE using a field GC. A summary of the GC calibration, sample preparation and the use of blanks and QA/QC procedures is presented in Appendix H. Results of the field analytical program are presented in Section 7.0.

5.4.7 Overburden Monitoring Well Installation

Based on the results of the surficial geophysical survey and the screened auger boring program, a total of 13 new groundwater monitoring wells were installed in the soil borings described in Subsection 5.4.5 (see Figure 5-3). Monitoring well construction was completed in accordance with USAEC requirements. Monitoring well completion diagrams are presented in Appendix C and summarized in Table 5-14. Monitoring well installation procedures are presented in Subsection 4.4.6.4 of Volume I of the Fort Devens POP (ABB-ES, 1993e).

5.4.8 Well Development

Each monitoring well installed during the RI was developed using the pump and surge method, to remove any water added to the boring during drilling and/or well installation, and to remove sediment from the monitoring well screen prior to groundwater sampling. Dedicated pumps and tubing were used to limit the possibility of cross contamination. Procedures for well development are presented in Subsection 4.4.6.5 of Volume I of the POP (ABB-ES, 1993e).

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Monitoring well development is documented on Well Development Field Data Records presented in Appendix F. Water was not added to the wells to aid in development. Well development did not begin sooner than 48 hours after completion of the mortar collar placement.

5.4.9 Groundwater Sampling

Two rounds of groundwater samples (Rounds Five and Six) were collected from the 13 new and six existing monitoring wells (see Figure 5-4). Round Five samples were collected in January 1995 and Round Six were collected in March 1995. The groundwater samples for these two rounds were submitted for off-site laboratory analysis consisting of PAL VOCs, SVOCs, inorganics (both filtered and unfiltered), water quality parameters, and TSS. Groundwater sampling procedures are presented in Subsection 4.5.2.2 of Volume I of the POP (ABB-ES, 1993e). Sample results are discussed in Section 7.0 of this report.

5.4.10 In-Situ Hydraulic Conductivity Testing

Hydraulic conductivity tests were performed on each of the monitoring wells installed during the RI to obtain estimates of hydraulic conductivity of the geologic units at AOC 41. Appendix D-1 presents data and analyses of the hydraulic conductivity testing. These tests generally consisted of falling and rising head tests within a given monitoring well. Falling head test data was analyzed for monitoring wells with static water levels above the top of the well screen. Rising head tests were performed on all monitoring wells except 41M-94-10X due to very slow (>2 hours) water level recovery. The rate of water level recovery back to static conditions within the well casing was monitored using a pressure transducer and data logger. The elevation of the water level (for falling head tests) and depression (for rising head tests) was accomplished with a solid cylindrical PVC slug using the techniques discussed in Subsection 4.8.2 of Volume I of the Fort Devens POP (1993e).

The data from all in-situ hydraulic conductivity tests were analyzed using the Method of Bouwer and Rice 1976 with the Aqtesolv computer program. In addition, data were analyzed by the Hvorslev (1951) method. Discussion of the results of the in-situ hydraulic conductivity testing are presented in Section 6.0 of this RI Report.

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5.4.11 Equipment Decontamination

Several different sampling and analytical procedures were used during the AOC 41 RI field program, which lead to a variety of decontamination procedures. To document the effectiveness of decontamination procedures, periodic equipment rinsate blanks were collected during previous investigations and submitted for chemical analyses. Analytical results for the rinsate blanks are presented in Appendices H. The following subsections describe each decontamination process.

One central decontamination pad was constructed and maintained by D.L. Maher, Inc. (drilling subcontractor). The pad was constructed at AOC 41 for the decontamination (via steam cleaning) of the drill rig and other equipment including, but not limited to, drill rods, well materials, split spoons, augers, drill bits, and vehicles. This decontamination pad was approximately 10 feet long and 10 feet wide and was built with three low sides and a floor that sloped to the southwest to collect liquid residuals. The bottom was lined with high density plastic sheeting. Decontamination procedures followed during the RI are presented in Subsection 4.3 of Volume I of the Fort Devens POP (ABB-ES, 1993e).

5.4.12 Investigation-Derived Waste

During the field program at the AOC 41 a variety of investigation-derived waste (IDW) was produced including purge water, soil cuttings, well development water, decontamination fluids from the decontamination pad, grout, and personnel protective equipment. Procedures outlined in Subsection 4.10 of Volume I of the Fort Devens POP were followed during each RI field activity (ABB-ES, 1993e).

5.4.13 Location and Elevation Survey

Upon completion of the field program at the AOC 41, a location and elevation survey was conducted to accurately locate the explorations including new and existing monitoring wells, screened augers, test pits and geophysical grids. A topographic survey was also conducted at the AOC to better define the topographic features at the site.

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Horizontal control was established with a Leitz Sokkia II Total Station Vernier reading to one second accuracy. Vertical control was established using a Topcon Auto Level accurate to 0.001 of a foot. Both units were calibrated in December 1993 by North American Survey Supply, authorized dealer and service representative for Leitz and Topcon.

Survey procedures and accuracy are presented in Subsection 4.9 of Volume I of the Fort Devens POP (ABB-ES, 1993e). Appendix I presents a summary of the survey data.

5.4.14 Long Term Monitoring

During the course of the previous investigations, it became apparent that the relationship between the water level within New Cranberry Pond had an impact on local groundwater flow. Also, the lag time between the pond variations and those observed in monitoring wells at the site were important. Therefore, a long-term water level monitoring program was initiated prior to the beginning of the RI field investigation. On April 14, 1994 a pressure transducer and In-Situ Hermit™ Well Sentinal data logger were installed in 41M-92-01X, and water level measurement recording began. On May 26, 1994 two additional pressure transducers and similar data loggers were installed at 41M-93-03X and at a PVC well screen standpipe on the north shore New Cranberry Pond (see Figure 5-4). The data loggers recorded data uninterrupted from each measurement point until December 1, 1994. The data recorded is presented in Appendix D-3.

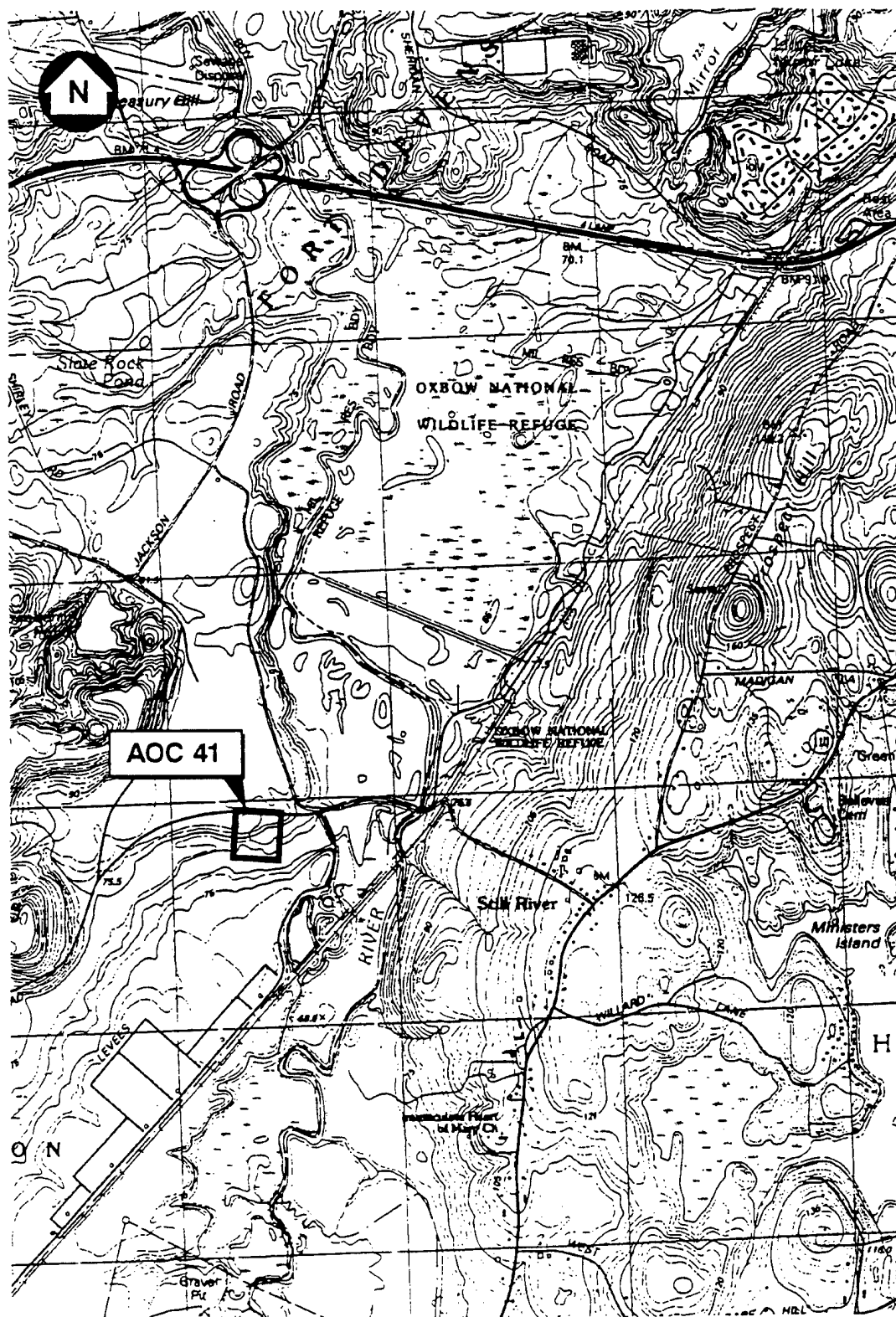


FIGURE 5-1
 LOCATION OF AOC 41
 AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
 REMEDIAL INVESTIGATION REPORT
 FORT DEVENS, MA

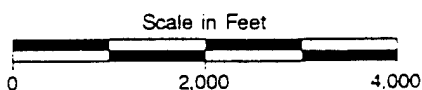
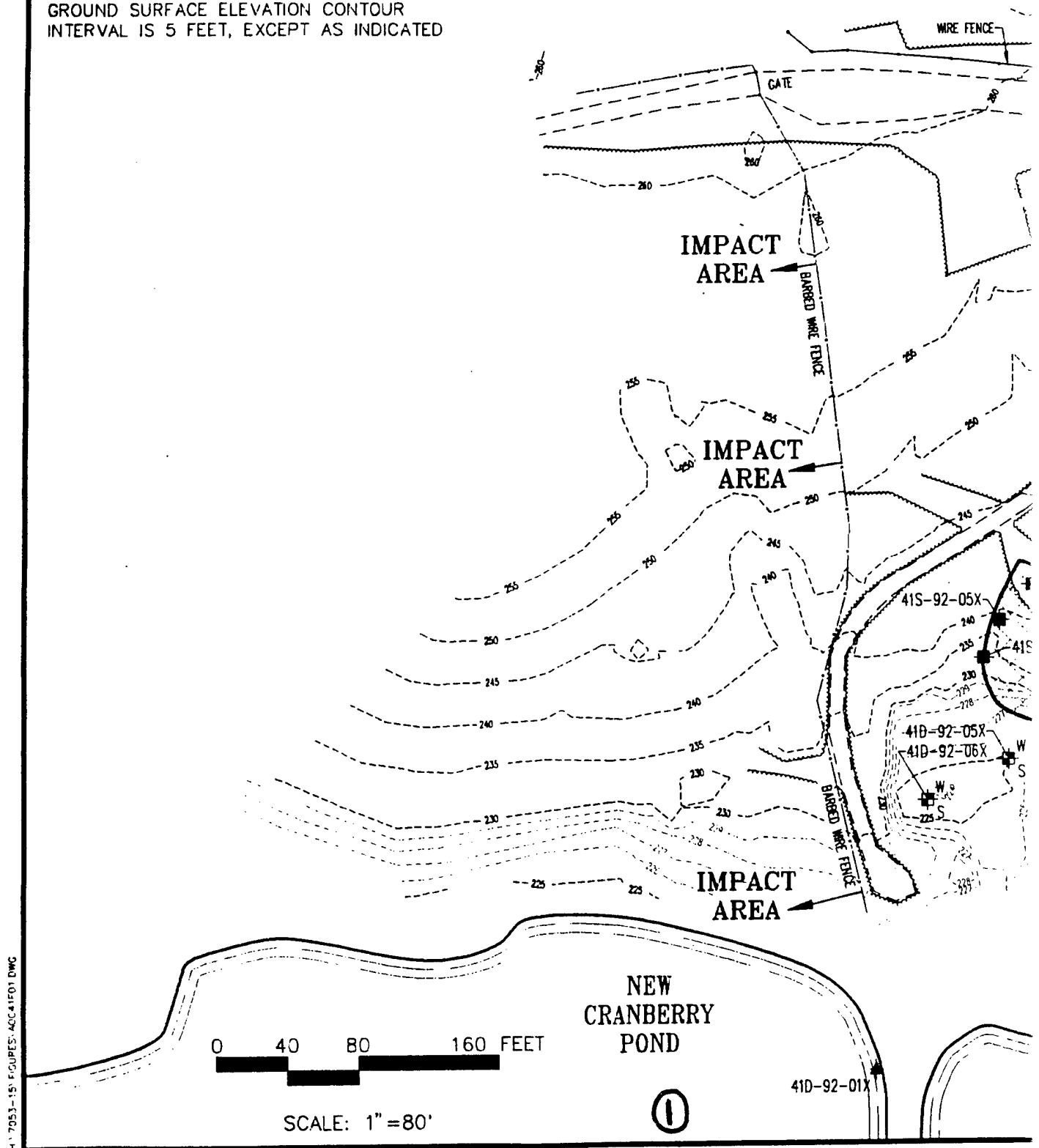


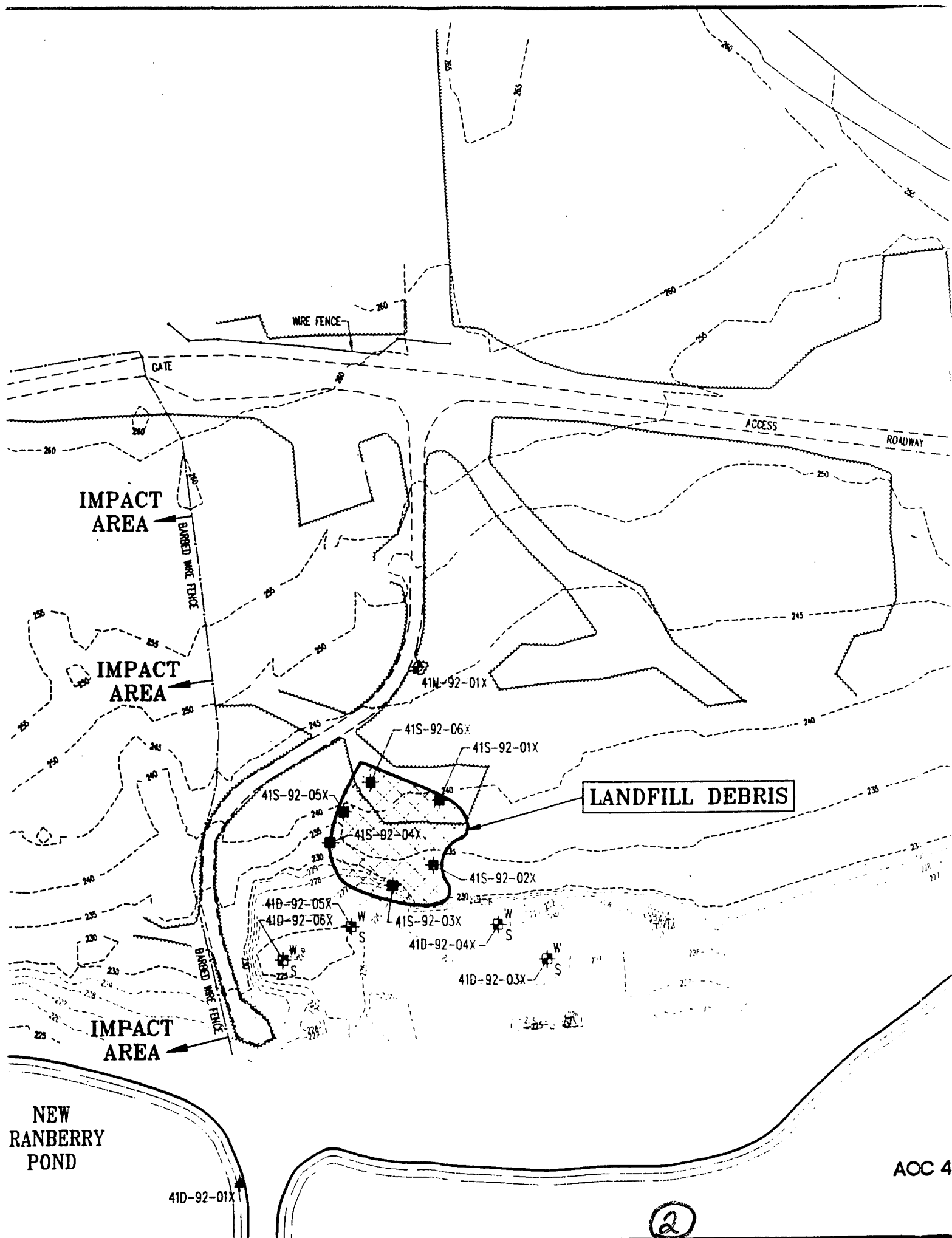
ABB Environmental Services, Inc.

LEGEND

- ⊕ MONITORING WELL
41M-92-01X
- ⊕^W_S SUMP SAMPLE
41D-92-03X (WATER AND SOIL OUT OF HAND DUG SUMP)
- ⊕ SOIL SAMPLE
41S-92-01X
- ▲ SURFACE WATER/SEDIMENT SAMPLE
41D-92-01X
- ~ TREELINE

NOTE:
GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET, EXCEPT AS INDICATED





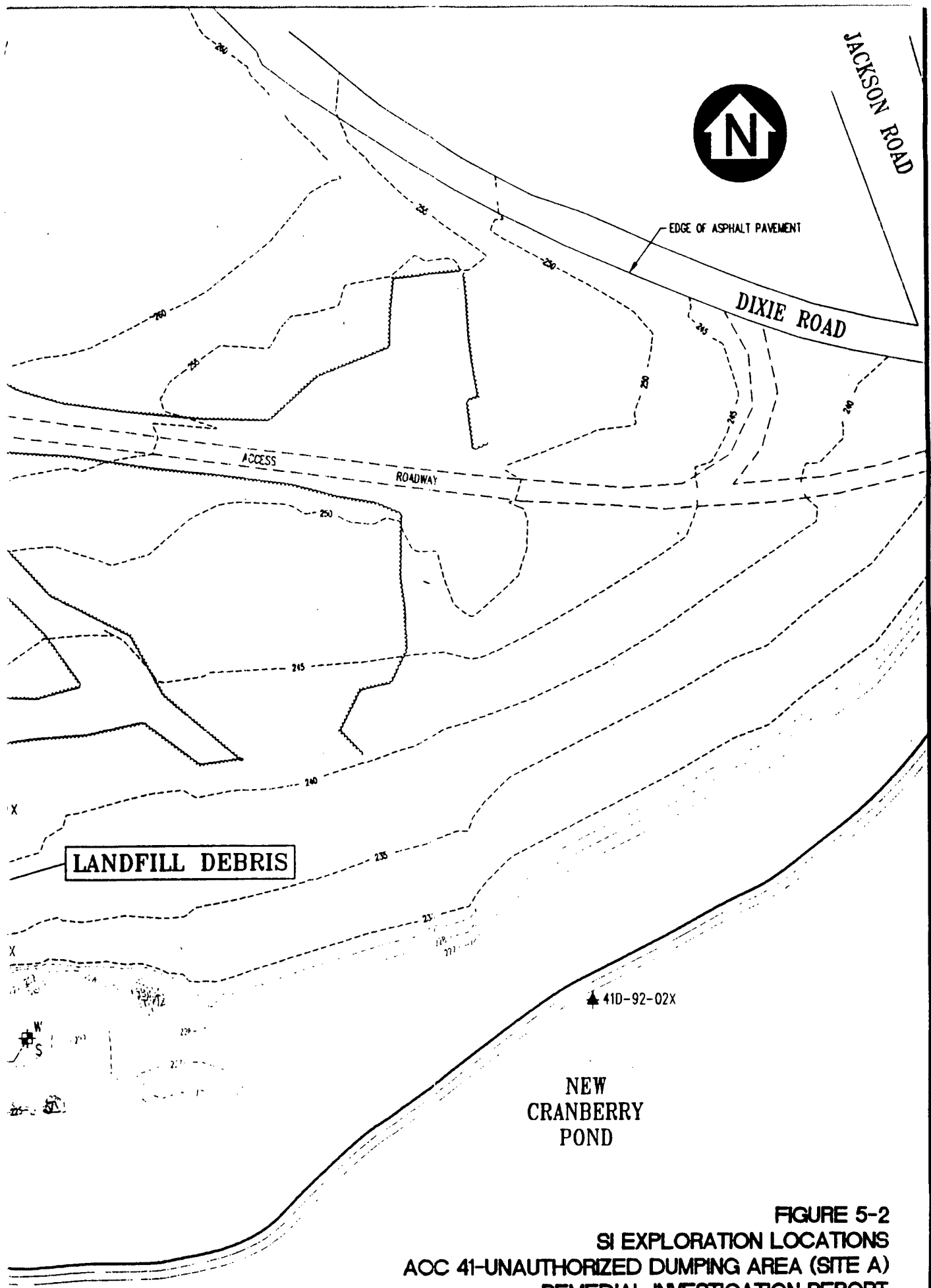


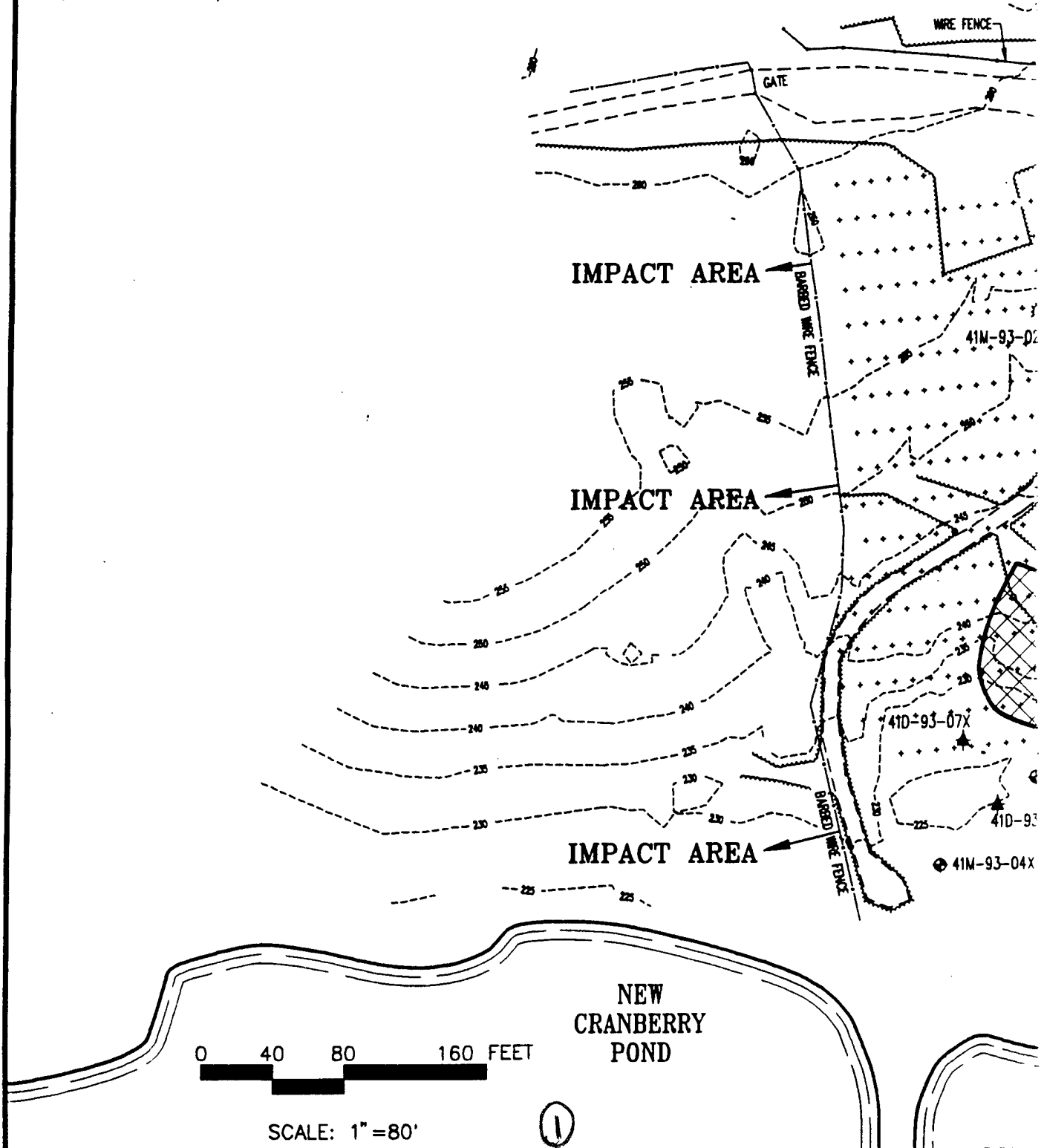
FIGURE 5-2
SI EXPLORATION LOCATIONS
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

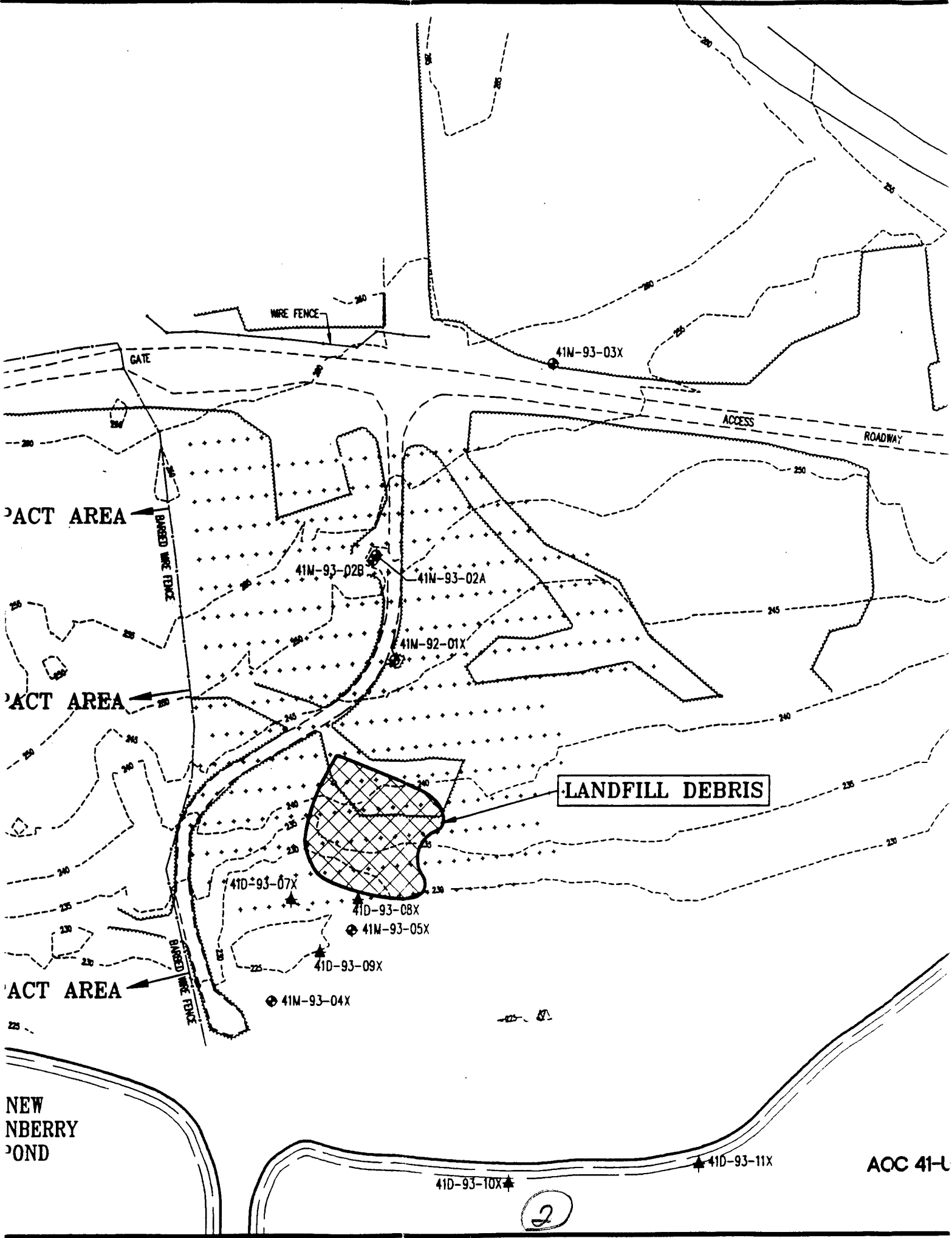
LEGEND

- ◆ MONITORING WELL
41M-94-03X
- ★ SURFACE WATER/SEDIMENT SAMPLE
41D-93-07X
- ~ TREELINE
- + + + + + GEOPHYSICAL SURVEY POINTS

NOTE:

GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET, EXCEPT AS INDICATED.





AOC 41-L

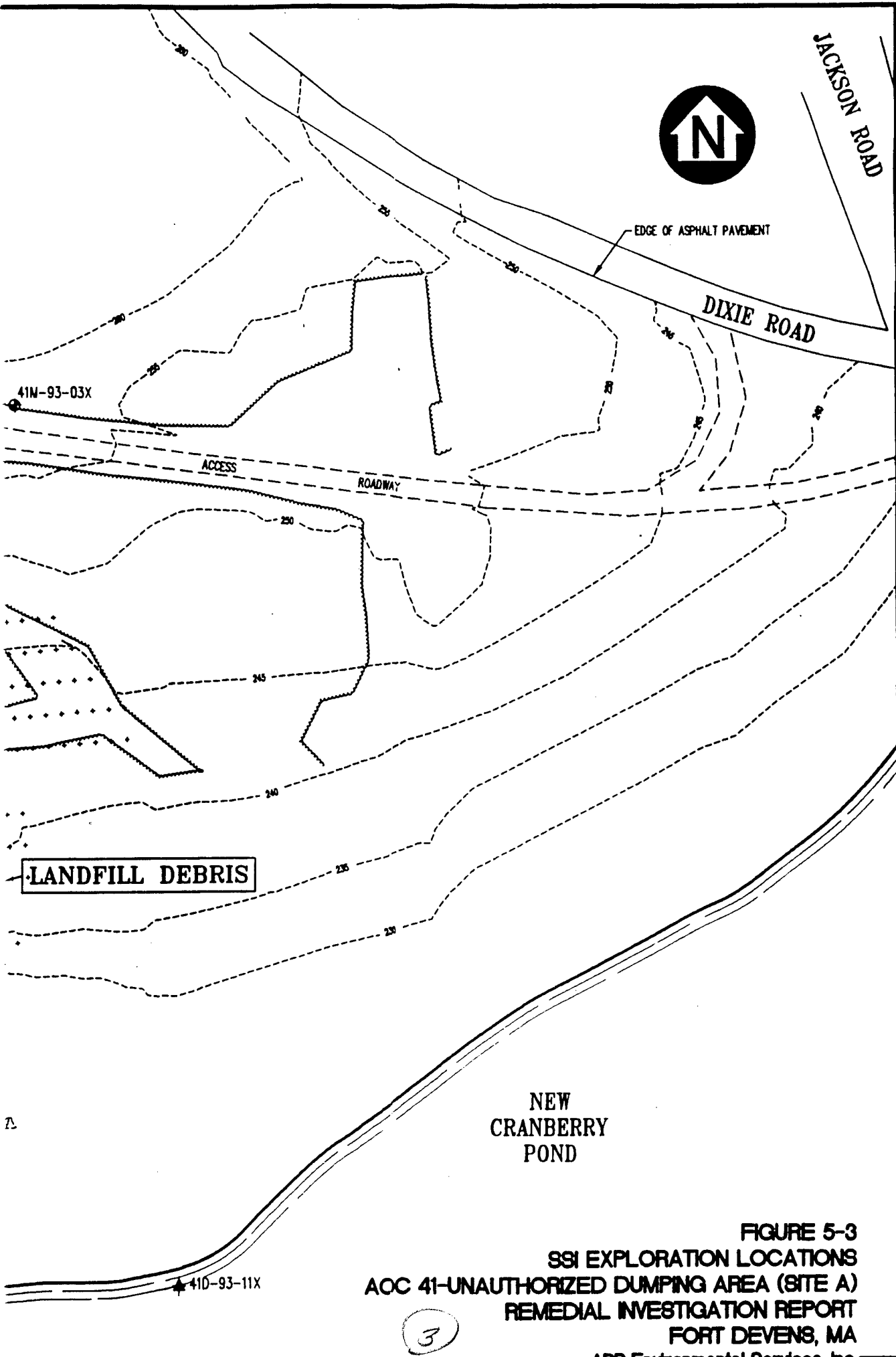






FIGURE 5-3
SSI EXPLORATION LOCATIONS
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA


LEGEND


 MONITORING WELL
 41M-94-03X

 SCREENED AUGER BORING (WATER ONLY)
 SA4123

 SCREENED AUGER BORING (WATER AND SOIL)
 SA4122

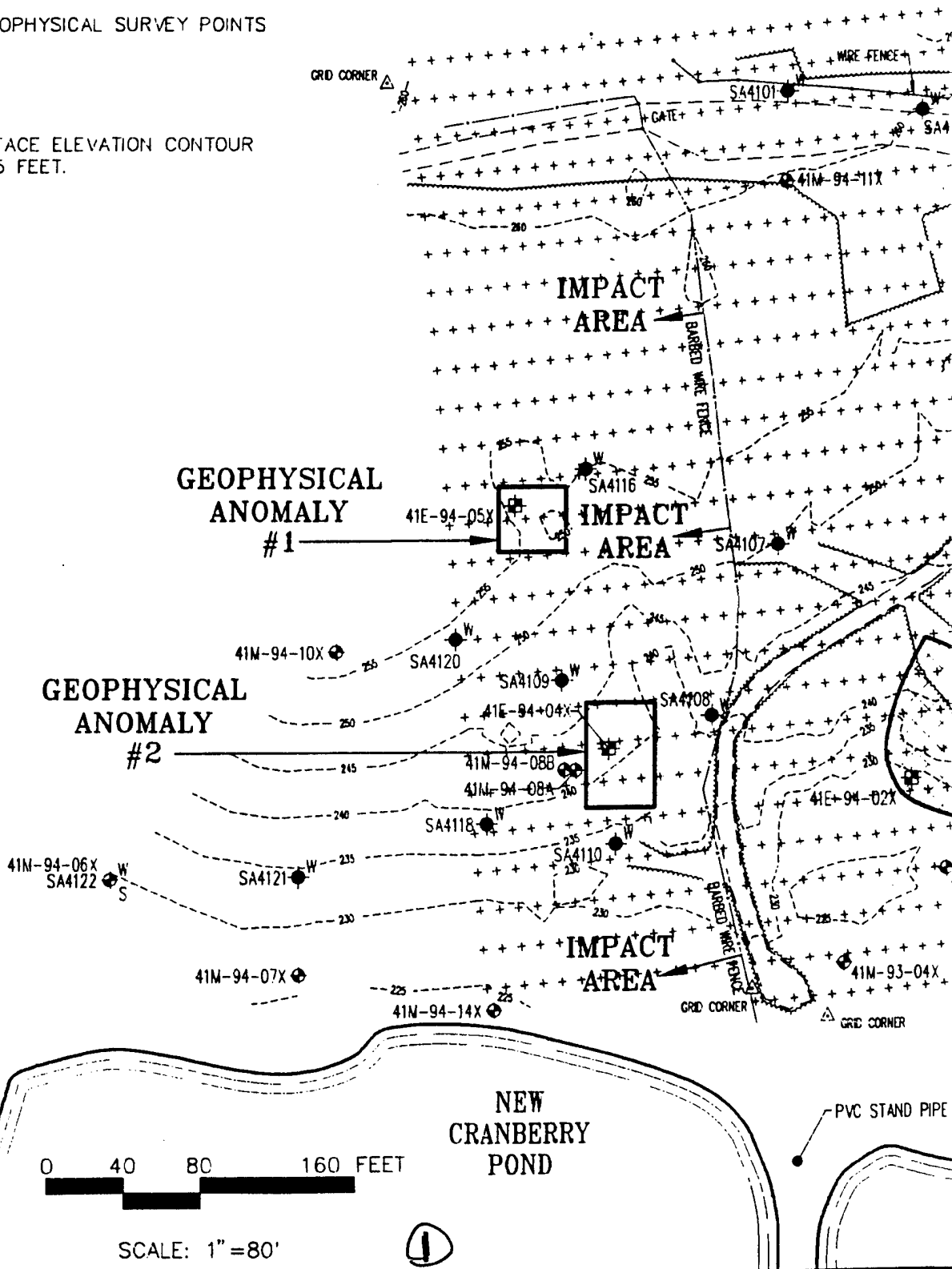
 TEST PIT
 41E-94-02X

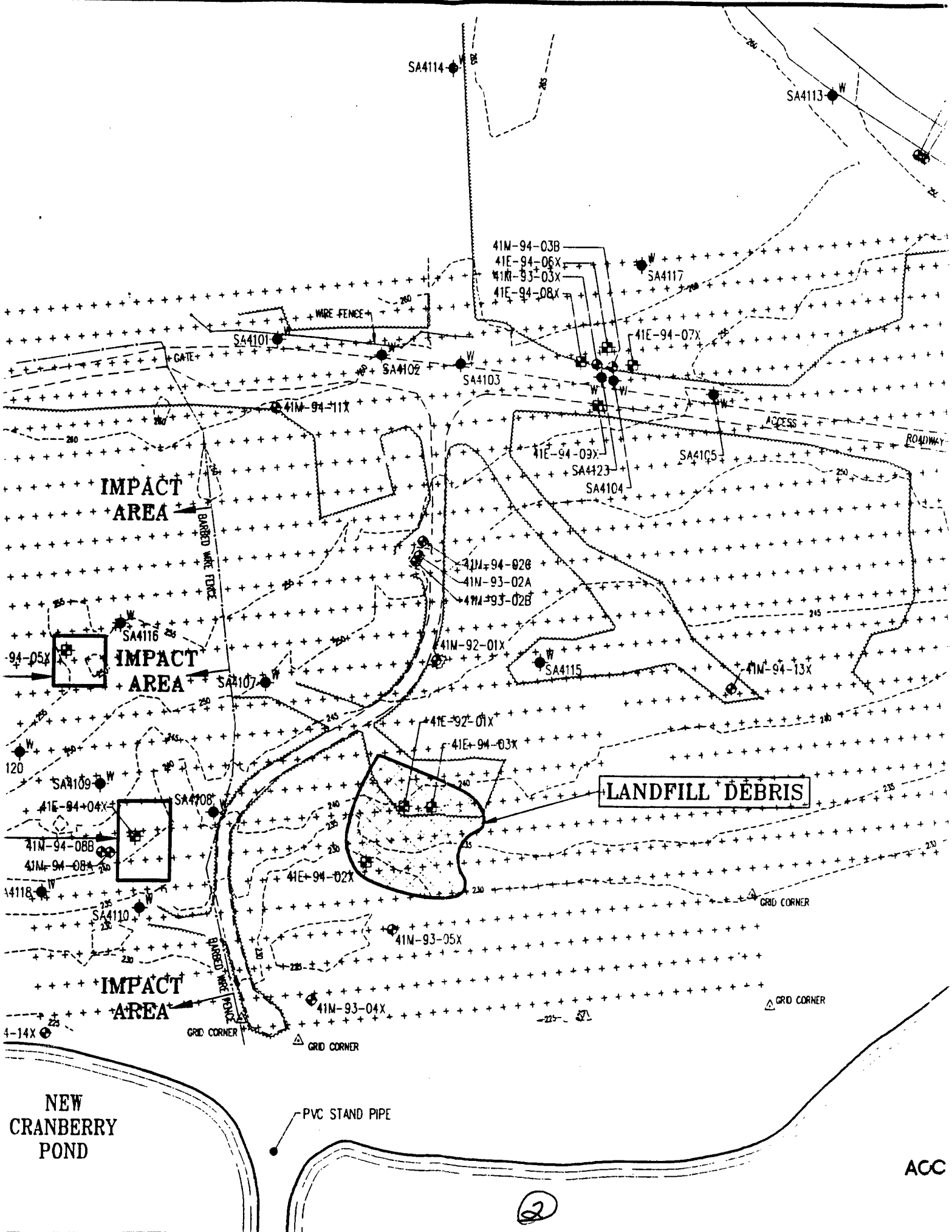
 TREELINE

 GEOPHYSICAL SURVEY POINTS

NOTE:

GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.





IMPACT AREA

IMPACT AREA

LANDFILL DEBRIS

IMPACT AREA

NEW
CRANBERRY
POND

PVC STAND PIPE

ACC

2

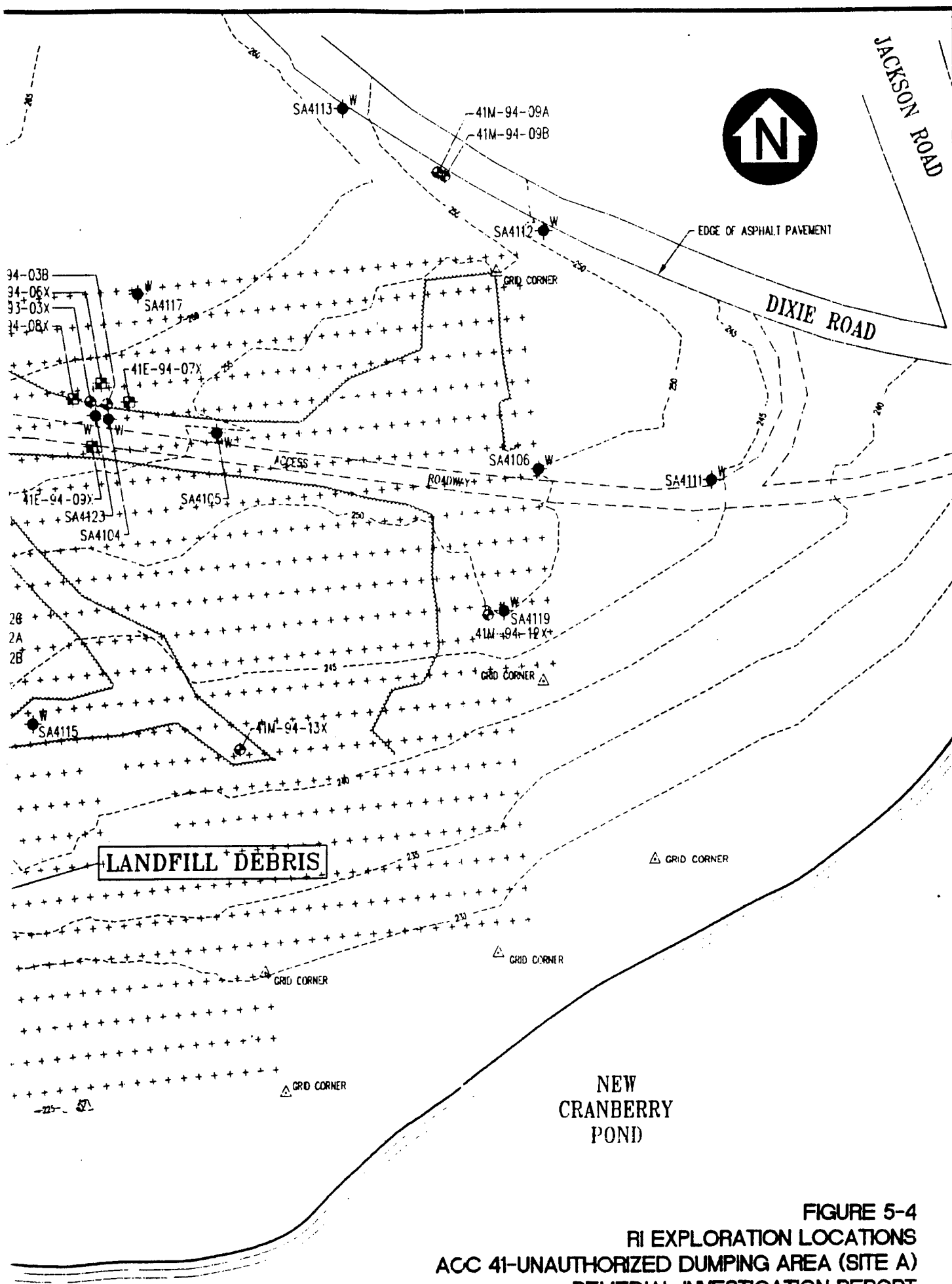
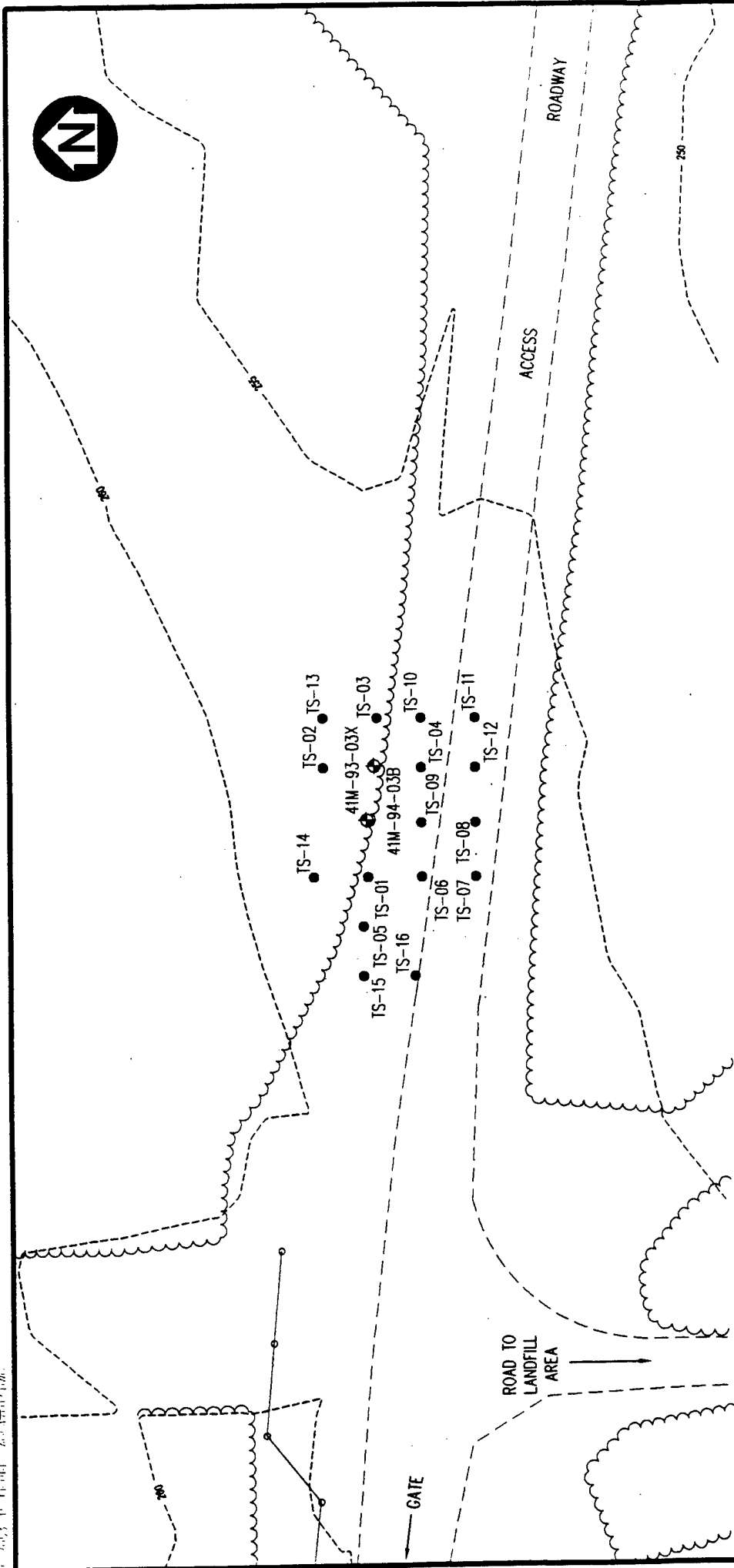


FIGURE 5-4
 RI EXPLORATION LOCATIONS
 ACC 41-UNAUTHORIZED DUMPING AREA (SITE A)
 REMEDIAL INVESTIGATION REPORT
 FORT DEVENS, MA



LEGEND

- MONITORING WELL
- TERRAPROBE POINT
- TREELINE

NOTE:

GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.

0 15 30 60 FEET

SCALE: 1" = 30'

FIGURE 5-5
RI TERRAPROBE LOCATIONS
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA
ABB Environmental Services, Inc.

TABLE 5-1
SUMMARY OF INVESTIGATION ACTIVITIES
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION/SAMPLE IDENTIFICATION	PURPOSE OF ACTIVITY
SITE INVESTIGATION					
AUGUST 1992	SOIL BORING / MONITORING WELL INSTALLATION	ABB-ES	1 WELL	41M-92-01X	COLLECT SUBSURFACE SOIL SAMPLES AND INSTALL MONITORING WELL TO ASSESS IMPACT FROM SITE USE
	SURFACE SOIL SAMPLING	ABB-ES	10 SAMPLES	41S-92-01X TO 41S-92-06X, 41D-92-03X TO 41D-92-06X	ASSESS WHETHER THE SURFACE OF THE LANDFILL POSES A RISK TO HUMAN OR ECOLOGICAL RECEPTORS
	SUMP SAMPLING	ABB-ES	4 SUMPS	41D-92-03X TO 41D-92-06X	GROUNDWATER AND SOIL SAMPLES COLLECTED TO ASSESS THE IMPACT OF THE SITE USE ON DOWNGRADE GROUNDWATER AND SOIL
	SURFACE WATER - SEDIMENT SAMPLING	ABB-ES	2 SW/SED PAIRS	41D-92-01X AND 41D-92-02X	ASSESS WHETHER THE LANDFILL HAS IMPACTED SURFACE WATER OR SEDIMENT QUALITY IN NEW CRANBERRY POND
SEPTEMBER 1992	GROUNDWATER SAMPLING	ABB-ES	1 WELL	41M-92-01X, 41D-92-03X through 41D-92-06X	COLLECT SAMPLES TO ASSESS IMPACT TO GROUNDWATER FROM SITE USE
OCTOBER 1992	IN-SITU HYDRAULIC CONDUCTIVITY TESTING	ABB-ES	1 WELL	41M-92-01X	TESTING TO ESTIMATE AQUIFER HYDRAULIC CONDUCTIVITIES
JANUARY 1993	GROUNDWATER SAMPLING	ABB-ES	1 WELL	41M-92-01X	COLLECT SAMPLES TO ASSESS IMPACT TO GROUNDWATER FROM SITE USE
SUPPLEMENTAL SITE INVESTIGATION					
AUGUST 1993	SEDIMENT SAMPLING	ABB-ES	3 SAMPLES	41D-93-07X TO 41D-93-09X	COLLECT SAMPLES TO ASSESS THE IMPACT OF THE LANDFILL ON SEDIMENTS IN LOW AREA
	SURFACE WATER - SEDIMENT SAMPLING	ABB-ES	2 SW/SED PAIRS	41D-93-10X AND 41D-93-11X	ASSESS WHETHER THE LANDFILL HAS IMPACTED SURFACE WATER OR SEDIMENT QUALITY IN NEW CRANBERRY POND
SEPTEMBER 1993	GEOPHYSICAL SURVEY	ABB-ES	1 SURVEY	NORTHERN PORTION OF AOC 41	DEFINE SOURCE AREA OF CHLORINATED SOLVENT CONTAMINANTS DETECTED IN GROUNDWATER DURING THE SI
	SOIL BORING / MONITORING WELL INSTALLATION	ABB-ES	5 WELLS	41M-93-02A, -02B, -03X, -04X, AND -05X	COLLECT SUBSURFACE SOIL SAMPLES AND INSTALL MONITORING WELL TO ASSESS IMPACT FROM SITE USE
OCTOBER 1993	GROUNDWATER SAMPLING	ABB-ES	6 WELLS	41M-92-01X, 41M-93-02A, -02B, -03X, -04X, AND -05X	COLLECT SAMPLES TO ASSESS IMPACT TO GROUNDWATER FROM SITE USE
	IN SITU HYDRAULIC CONDUCTIVITY TESTING	ABB-ES	5 WELLS	41M-93, -02B, -03X, -04X, AND -05X	TESTING TO ESTIMATE AQUIFER HYDRAULIC CONDUCTIVITIES
JANUARY 1994	GROUNDWATER SAMPLING	ABB-ES	6 WELLS	41M-92-01X, 41M-93-02A, -02B, -03X, -04X, AND -05X	COLLECT SAMPLES TO ASSESS IMPACT TO GROUNDWATER FROM SITE USE

TABLE 5-1
SUMMARY OF INVESTIGATION ACTIVITIES
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION/SAMPLE IDENTIFICATION	PURPOSE OF ACTIVITY
REMEDIAL INVESTIGATION					
SEPTEMBER 1994	GEOPHYSICAL SURVEY	ABB-ES	1 SURVEY	AREA SURROUNDING AOC 41	DEFINE POTENTIAL GROUNDWATER CONTAMINANT SOURCE AREAS AND AID IN PLACEMENT OF THE BORINGS AND MONITORING WELLS
SEPTEMBER/ NOVEMBER 1994	SCREENED AUGER BORINGS	ABB-ES	23 BORINGS	SA4101 TO SA4123	COLLECT GROUNDWATER SAMPLES FOR FIELD ANALYSES TO DETERMINE EXTENT OF CONTAMINATION AND AID IN PLACEMENT OF MONITORING WELLS
OCTOBER 1994	TEST PITTING	ABB-ES	5 TEST PITS	41E-94-01X TO 41E-94-05X	COLLECT SOIL SAMPLES FOR OFF-SITE LABORATORY ANALYSIS AND CHARACTERIZE POTENTIAL SOURCE AREAS AND THE WASTE MATERIAL
OCTOBER/ NOVEMBER 1994	SOIL BORING / MONITORING WELL INSTALLATION	ABB-ES	13 WELLS	41M-94-02C, -03B, -06X TO -14X	INSTALL MONITORING WELLS TO ASSESS AND MONITOR GROUNDWATER CONTAMINATION AND TO FURTHER DEFINE SITE-SPECIFIC GROUNDWATER FLOW
DECEMBER 1994	GROUNDWATER SAMPLING	ABB-ES	19 WELLS	41M-92-01X TO 41M-94-14X	COLLECT GROUNDWATER SAMPLES TO DEFINE AND MONITOR GROUNDWATER CONTAMINATION
	TEST PITTING	ABB-ES	4 TEST PITS	41E-94-06X TO 41E-94-09X	COLLECT SOIL SAMPLES TO DETERMINE CONTAMINANT SOURCE AREA NORTH OF ACCESS ROAD NEAR 41M-93-03X AND 41M-94-03B
FEBRUARY/MARCH	IN-SITU HYDRAULIC CONDUCTIVITY TESTING	ABB-ES	13 WELLS	41M-94-02C, -03B, -06X TO -14X	TESTING TO ESTIMATE AQUIFER HYDRAULIC CONDUCTIVITIES
MARCH 1995	GROUNDWATER SAMPLING	ABB-ES	19 WELLS	41M-92-01X TO 41M-94-14X	COLLECT GROUNDWATER SAMPLES TO DEFINE AND MONITOR GROUNDWATER CONTAMINATION
APRIL 1995	TERRAPROBE POINTS	ABB-ES	16 POINTS	TS-01 TO TS-16	DEFINE POTENTIAL GROUNDWATER CONTAMINATION SOURCE AREA

NOTES:

TABLE 5-2
SUMMARY OF ANALYTICAL PROGRAM
AOC 41- UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	MEDIUM	EXPLORATION ID	DEPTH	ROUND	PARAMETERS													FIELD ANALYTICAL				
						OFF-SITE LABORATORY- PAL ANALYSES						LABORATORY- PAL ANALYSES											
						VOA	SVOA	P/P	INOR-tot	INOR-diss	TCLP	TPHC	WATER QUAL	TOC	EXP	TSSC/ABTEX	CHLOR	TPHC/TR					
SI	Water	Surface Water	41D-92-01X	26-28		X	X	X	X	X		X	X										
SI	Water	Surface Water	41D-92-02X			X	X	X	X														
SI	Soil	Sediment	41D-92-01X			X	X	X	X														
SI	Soil	Sediment	41D-92-02X			X	X	X	X														
SI	Water	Sump Water	41D-92-03X			X	X	X	X														
SI	Water	Sump Water	41D-92-04X			X	X	X	X														
SI	Water	Sump Water	41D-92-05X			X	X	X	X														
SI	Water	Sump Water	41D-92-06X			X	X	X	X														
SI	Water	Groundwater	41M-92-01X			X	X	X	X														
SI	Water	Groundwater	41M-92-01X			2		X	X														
SI	Soil	Soil	41M-92-01X																				
SI	Soil	Surface Soil	41S-92-01X					X	X														
SI	Soil	Surface Soil	41S-92-02X					X	X														
SI	Soil	Surface Soil	41S-92-03X					X	X														
SI	Soil	Surface Soil	41S-92-04X					X	X														
SI	Soil	Surface Soil	41S-92-05X					X	X														
SI	Soil	Surface Soil	41S-92-06X			X	X																
SI	Soil	Surface Soil	41D-92-03X			X	X																
SI	Soil	Surface Soil	41D-92-04X			X	X																
SI	Soil	Surface Soil	41D-92-05X			X	X																
SI	Soil	Surface Soil	41D-92-06X			X	X																
SSI	Soil	Sediment	41D-93-07X			X	X	X	X	X													
SSI	Soil	Sediment	41D-93-08X			X	X	X	X														
SSI	Soil	Sediment	41D-93-09X			X	X	X	X														
SSI	Soil	Sediment	41D-93-10X			X	X	X	X														
SSI	Soil	Sediment	41D-93-11X			X	X	X	X														
SSI	Water	Surface Water	41D-93-10X			X	X	X	X														
SSI	Water	Surface Water	41D-93-11X			X	X	X	X														
SSI	Water	Groundwater	41M-92-01X			3		X	X														
SSI	Water	Groundwater	41M-92-01X			4		X	X														
SSI	Water	Groundwater	41M-93-02A			3		X	X														
SSI	Water	Groundwater	41M-93-02A			4		X	X														
SSI	Water	Groundwater	41M-93-02B			3		X	X														
SSI	Water	Groundwater	41M-93-02B			4		X	X														

TABLE 5-2
SUMMARY OF ANALYTICAL PROGRAM
AOC 41- UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	MEDIUM	EXPLORATION ID	DEPTH	ROUND	PARAMETERS												
						OFF-SITE LABORATORY- PAL ANALYSES						FIELD ANALYTICAL						
						VOA	SVOA	P/P	INOR-tot	INOR-diss	TCLP	TPHC	WATER QUAL	TOC	EXP	TSSC/ABTEX	CHLOR	TPHC/IR
SSI	Soil	Soil	41M-93-02B	2-4		X	X	X	X						X			
SSI	Soil	Soil	41M-93-02B	4-6		X	X	X	X						X			
SSI	Soil	Soil	41M-93-02B	30-32		X	X	X	X					X	X			
SSI	Water	Groundwater	41M-93-03X		3	X	X	X	X	X					X			
SSI	Water	Groundwater	41M-93-03X		4	X	X	X	X	X				X	X			
SSI	Soil	Soil	41M-93-03X	45-47		X	X	X	X	X					X			
SSI	Water	Groundwater	41M-93-04X		3	X	X	X	X	X					X			
SSI	Water	Groundwater	41M-93-04X		4	X	X	X	X	X				X	X			
SSI	Soil	Soil	41M-93-04X	5-7		X	X	X	X									
SSI	Water	Groundwater	41M-93-05X		3	X	X	X	X	X					X			
SSI	Water	Groundwater	41M-93-05X		4	X	X	X	X	X				X	X			
SSI	Soil	Soil	41M-93-05X	5-7		X	X	X	X					X				
RI	Water	S_Auger	SA4101	38-43														
RI	Water	S_Auger	SA4102	41-46												X	X	X
RI	Water	S_Auger	SA4103	37-42												X	X	X
RI	Water	S_Auger	SA4104	37-42												X	X	X
RI	Water	S_Auger	SA4105	40-45												X	X	X
RI	Water	S_Auger	SA4106	39-44												X	X	X
RI	Water	S_Auger	SA4107	35-40												X	X	X
RI	Water	S_Auger	SA4108	19-24												X	X	X
RI	Water	S_Auger	SA4109	26-31												X	X	X
RI	Water	S_Auger	SA4110	19-24												X	X	X
RI	Water	S_Auger	SA4111	36-41												X	X	X
RI	Water	S_Auger	SA4112	38-43												X	X	X
RI	Water	S_Auger	SA4113	40-45												X	X	X
RI	Water	S_Auger	SA4114	44-49												X	X	X
RI	Water	S_Auger	SA4115	25-30												X	X	X
RI	Water	S_Auger	SA4116	40-45												X	X	X
RI	Water	S_Auger	SA4117	45-50												X	X	X
RI	Water	S_Auger	SA4118	24-29												X	X	X
RI	Water	S_Auger	SA4119	45-50												X	X	X
RI	Water	S_Auger	SA4120	38-43												X	X	X
RI	Water	S_Auger	SA4121	19-24												X	X	X
RI	Water	S_Auger	SA4122	13-18												X	X	X

TABLE 5-2
SUMMARY OF ANALYTICAL PROGRAM
AOC 41- UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	MEDIUM	EXPLORATION ID	DEPTH	ROUND	PARAMETERS												FIELD ANALYTICAL	
						OFF-SITE LABORATORY - PAL ANALYSES													
						VOA	SVOA	P/P	INOR-tot	INOR-diss	TCLP	TPHC	WATER QUAL	TOC	EXP	ISSC/ABTEX	CHLOR	TPHC/IR	
RI	Water	S_Auger	SA4123	50-55														X	X
RI	Water	S_Auger	SA4123	55-60														X	X
RI	Water	S_Auger	SA4123	60-65														X	X
RI	Water	S_Auger	SA4123	65-70														X	X
RI	Water	S_Auger	SA4123	70-75														X	X
RI	Soil	Soil	41E-94-01X	2		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-01X	4		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-01X	10		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-02X	2		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-02X	9		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-03X	2		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-03X	11		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-04X	1		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-04X	3		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-05X	3		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-05X	5		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-05X	10		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-06X	3		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-06X	9		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-07X	4		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-07X	10		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-08X	4		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-08X	10		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-08X	12		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-09X	4		X	X		X		X			X				X	X
RI	Soil	Soil	41E-94-09X	9		X	X		X		X			X				X	X
RI	Water	Groundwater	41M-92-01X	5		X	X		X		X			X			X	X	X
RI	Water	Groundwater	41M-92-01X	6		X	X		X		X			X			X	X	X
RI	Water	Groundwater	41M-93-02A	5		X	X		X		X			X			X	X	X
RI	Water	Groundwater	41M-93-02A	6		X	X		X		X			X			X	X	X
RI	Water	Groundwater	41M-93-02B	5		X	X		X		X			X			X	X	X
RI	Water	Groundwater	41M-93-02B	6		X	X		X		X			X			X	X	X
RI	Water	Groundwater	41M-93-02C	5		X	X		X		X			X			X	X	X
RI	Water	Groundwater	41M-93-02C	6		X	X		X		X			X			X	X	X

TABLE 5-2
SUMMARY OF ANALYTICAL PROGRAM
AOC 41- UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	MEDIUM	EXPLORATION ID	DEPTH	ROUND	PARAMETERS														FIELD ANALYTICAL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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						VOA	SVOA	P/P	INOR-tot	INOR-diss	TCLP	TPHC	WATER QUAL	TOC	EXP	TSS	C/ABTEX	CHLOR	TPHC/IR																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
RI	Water	Groundwater	41M-93-03X		5	X	X		X	X			X			X																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

TABLE 5-2
SUMMARY OF ANALYTICAL PROGRAM
AOC 41- UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	MEDIUM	EXPLORATION ID	DEPTH	ROUND	PARAMETERS										FIELD ANALYTICAL		
						VOA	SVOA	P/P	INOR-tot	INOR-diss	TCLP	TPHC	WATER QUAL	TOC	EXP	TSSC/ARTEX	CHLOR	TPHC/IR
RI	Water	Groundwater	41M-94-04X														X	
RI	Water	Groundwater	41M-94-05X														X	
RI	Gas	T_Probe	TS-01	5-7														
RI	Gas	T_Probe	TS-01	7-9														
RI	Gas	T_Probe	TS-01	9-11														
RI	Gas	T_Probe	TS-01	11-13														
RI	Gas	T_Probe	TS-01	13-15														
RI	Gas	T_Probe	TS-01	19-21														
RI	Gas	T_Probe	TS-02	5-7														
RI	Gas	T_Probe	TS-03	5-7														
RI	Gas	T_Probe	TS-04	5-7														
RI	Gas	T_Probe	TS-04	10-12														
RI	Gas	T_Probe	TS-04	15-17														
RI	Gas	T_Probe	TS-04	20-22														
RI	Gas	T_Probe	TS-05	5-7														
RI	Gas	T_Probe	TS-06	5-7														
RI	Gas	T_Probe	TS-07	5-7														
RI	Gas	T_Probe	TS-08	5-7														
RI	Gas	T_Probe	TS-09	5-7														
RI	Gas	T_Probe	TS-10	5-7														
RI	Gas	T_Probe	TS-11	5-7														
RI	Gas	T_Probe	TS-12	5-7														
RI	Gas	T_Probe	TS-13	5-7														
RI	Gas	T_Probe	TS-13	5-7														
RI	Soil	T_Probe	TS-01	18-20														
RI	Soil	T_Probe	TS-01	23-25														
RI	Soil	T_Probe	TS-01	30-32														
RI	Soil	T_Probe	TS-01	35-37														
RI	Soil	T_Probe	TS-02	30-32														
RI	Soil	T_Probe	TS-02	35-37														
RI	Soil	T_Probe	TS-03	30-32														
RI	Soil	T_Probe	TS-03	35-37														
RI	Soil	T_Probe	TS-04	18-20														
RI	Soil	T_Probe	TS-04	23-25														

TABLE 5-2
SUMMARY OF ANALYTICAL PROGRAM
AOC 41- UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	MEDIUM	EXPLORATION ID	DEPTH	ROUND	PARAMETERS												FIELD ANALYTICAL	
						OFF-SITE LABORATORY- PAL ANALYSES													
						VOA	SVOA	P/P	INOR-tot	INOR-diss	TCLP	TPHC	WATER QUAL	TOC	EXP	TSSC/ABTEX	CHLOR	TPHC/IR	
RI	Soil	T_Probe	TS-04	30-32														X*	
RI	Soil	T_Probe	TS-04	35-37														X*	
RI	Soil	T_Probe	TS-05	30-32														X*	
RI	Soil	T_Probe	TS-05	35-37														X*	
RI	Soil	T_Probe	TS-06	30-32														X*	
RI	Soil	T_Probe	TS-06	35-37														X*	
RI	Soil	T_Probe	TS-07	30-32														X*	
RI	Soil	T_Probe	TS-07	35-37														X*	
RI	Soil	T_Probe	TS-10	30-32														X*	
RI	Soil	T_Probe	TS-10	35-37														X*	
RI	Soil	T_Probe	TS-11	30-32														X*	
RI	Soil	T_Probe	TS-11	35-37														X*	
RI	Soil	T_Probe	TS-12	30-32														X*	
RI	Soil	T_Probe	TS-12	35-37														X*	
RI	Soil	T_Probe	TS-14	30-32														X*	
RI	Soil	T_Probe	TS-14	35-37														X*	
RI	Soil	T_Probe	TS-15	30-32														X*	
RI	Soil	T_Probe	TS-15	35-37														X*	
RI	Soil	T_Probe	TS-16	30-32														X*	
RI	Soil	T_Probe	TS-16	30-32														X*	
RI	Soil	S.Boring	41M-94-03B	5-7													X	X	
RI	Soil	S.Boring	41M-94-03B	10-12													X	X	
RI	Soil	S.Boring	41M-94-03B	15-17													X	X	
RI	Soil	S.Boring	41M-94-03B	20-22													X	X	
RI	Soil	S.Boring	41M-94-03B	25-27													X	X	
RI	Soil	S.Boring	41M-94-03B	30-32													X	X	
RI	Soil	S.Boring	41M-94-03B	35-37													X	X	
RI	Soil	S.Boring	41M-94-03B	40-42													X	X	
RI	Soil	S.Boring	41M-94-03B	45-47													X	X	
RI	Soil	S.Boring	41M-94-03B	50-52													X	X	
RI	Soil	S.Boring	41M-94-03B	55-57													X	X	
RI	Soil	S.Boring	41M-94-03B	60-62													X	X	
RI	Soil	S.Boring	41M-94-03B	65-67													X	X	
RI	Soil	S.Boring	41M-94-07X	5-7													X	X	

TABLE 5-2
SUMMARY OF ANALYTICAL PROGRAM
AOC 41- UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

FIELD EVENT	MATRIX	MEDIUM	EXPLORATION ID	DEPTH	ROUND	PARAMETERS													FIELD ANALYTICAL		
						OFF-SITE LABORATORY - PAL ANALYSES							WATER QUAL								
						VOA	SVOA	P/P	INOR-tot	INOR-diss	TCLP	TPHC	WATER QUAL	TOC	EXP	TSSC/ABTEX	CHLOR	TPHC/IR			
RI	Soil	S.Boring	41M-94-08A	24-26													X				
RI	Soil	S.Boring	41M-94-08B	39-41														X			
RI	Soil	S.Boring	41M-94-09A	35-37														X			
RI	Soil	S.Boring	41M-94-09B	40-42														X			
RI	Soil	S.Boring	41M-94-10X	40-42														X			
RI	Soil	S.Boring	41M-94-11X	34-36														X			
RI	Soil	S.Boring	41M-94-12X	40-42														X			
RI	Soil	S.Boring	41M-94-13X	19-20														X			
RI	Soil	S.Boring	41M-94-14X	4-6														X			

Notes:

VOA = Volatile Organic Analysis

SVOA = SemiVolatile Organic Analysis

P/P = Pesticide/PCBs

Inorg. = Inorganics

TOC = Total Organic Carbon

EX = Explosives

TSS = Total Suspended Solids

TDS = Total Dissolved Solids

TPHC=Total Petroleum Hydrocarbons

WATER QUAL=Sulfate, Alkalinity, Phosphate, Nitrite as Nitrogen, Total Kjeldhal Nitrogen

BTEX= Benzene, Toluene, ethylbenzene, M/P/O-Xylenes

CHLOR=Chlorinated VOCs

TCLP= Toxicity Characteristics Leachate Procedure

TPHC/IR=Total Petroleum Hydrocarbons by Infrared Spectrophotometry

X*=The chlorinated VOCs t-1,2-DCA, c-1,2-DCA, TCE only

TABLE 5-3
ORGANIC COMPOUNDS IN SURFACE SOIL
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIATION INVESTIGATION REPORT
FORT DEVENS, MA

Analyte	Location		41S-92-01X		41S-92-02X		41S-92-03X		41S-92-04X		41S-92-05X		41S-92-06X	
	Depth	0 FT	0 FT	0 FT	0 FT	0 FT	0 FT	0 FT	0 FT	0 FT	0 FT	0 FT	0 FT	0 FT
SEMIVOLATILES (ug/g)														
ACENAPHTHYLENE		< 0.03	0.3				< 0.03		< 0.03		0.064		< 0.03	
ANTHRACENE		< 0.03	0.3				< 0.03		< 0.03		< 0.03		< 0.03	
BENZO(A)ANTHRACENE		< 0.17	1.0				< 0.17		< 0.17		< 0.17		< 0.17	
BENZO(A)PYRENE		< 0.25	2.0				< 0.25		< 0.25		< 0.25		< 0.25	
BENZO(B)FLUORANTHENE		< 0.21	2.0				< 0.21		< 0.21		< 0.21		< 0.21	
BENZO(G,H,I)PERYLENE		< 0.25	0.7				< 0.25		< 0.25		< 0.25		< 0.25	
BENZO(K)FLUORANTHENE		< 0.06	0.5				< 0.06		< 0.06		< 0.06		< 0.06	
CARBAZOLE		< 0.03	0.1 S				< 0.03		< 0.03		< 0.03		< 0.03	
CHRYSENE		< 0.12	2.0				< 0.12		< 0.12		< 0.12		< 0.12	
FLUORANTHENE		0.11	6.0				0.17		0.1		0.34		0.12	
INDENO(1,2,3-C,D)PYRENE		< 0.29	1.0				< 0.29		< 0.29		< 0.29		< 0.29	
PHENANTHRENE		0.047	1.0				0.05		< 0.03		0.15		0.046	
PYRENE		0.068	3.0				0.11		0.052		0.18		0.067	
PESTICIDE/PCBS (ug/g)														
ALPHA-CHLORDANE		< 0.005	< 0.005				< 0.005		< 0.005		0.007 S		< 0.005	
GAMMA-CHLORDANE		0.014 S	0.007 S				0.019 S		< 0.01		0.044 S		0.014 S	
HEPTACHLOR		0.038	0.03				0.033		0.025		0.038		0.026	
4,4'-DDD		< 0.008	0.013				< 0.008		< 0.008		< 0.008		< 0.008	
4,4'-DDE		0.065	0.12				0.048		0.089		0.21		0.085	
4,4'-DDT		0.054	0.083				0.036		0.033		0.34		0.061	
OTHER (ug/g)														
TOTAL ORGANIC CARBON		NA	NA				NA		NA		NA		NA	
TOTAL PETROLEUM HYDROCARBON		58.3	77.0				< 27.7		< 27.9		64.0		40.7	

NOTES:

TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY

< = LESS THAN DETECTION LIMIT SHOWN

NA = NOT ANALYZED

S = RESULTS BASED ON INTERNAL STANDARD

TABLE 5-3
ORGANIC COMPOUNDS IN SURFACE SOIL
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	BORING DEPTH	41D-92-03X	41D-92-04X	41D-92-05X	41D-92-06X
ORGANICS ($\mu\text{g/g}$)					
ACETONE		< 0.01	0.02	< 0.01	< 0.01
SEMIVOLATILES ($\mu\text{g/g}$)					
ANTHRACENE		0.3	< 0.03	< 0.03	< 0.03
BENZO[A]ANTHRACENE		2.0	< 0.17	< 0.17	< 0.17
BENZO[A]PYRENE		2.0	< 0.25	< 0.25	< 0.25
BENZO[B]FLUORANTHENE		1.0	< 0.21	< 0.21	< 0.21
BENZO[K]FLUORANTHENE		2.0	< 0.06	< 0.06	< 0.06
CHRYSENE		2.0	< 0.12	< 0.12	< 0.12
FLUORANTHENE		5.0	< 0.10	< 0.10	< 0.10
PHENANTHRENE		2.0	< 0.03	< 0.03	< 0.03
PYRENE		5.0	< 0.07	< 0.07	< 0.07
PESTICIDE/PCBS ($\mu\text{g/g}$)					
GAMMA-CHLORDANE		< 0.01	< 0.01	< 0.01	0.008 S
HEPTACHLOR		0.04	< 0.006	0.029	0.043
OTHER ($\mu\text{g/g}$)					
TOTAL ORGANIC CARBON		16100.0	NA	652.0	829.0

NOTES:

Table lists detected analytes only - see project analyte list for summary.

< = Less than detection limit shown.

NA = Not Analyzed.

S = Results based on internal standard.

TABLE 5-4
INORGANIC ANALYTES IN SURFACE SOIL
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Analyte	Background	Location	41S-92-01X	41S-92-02X	41S-92-03X	41S-92-04X	41S-92-05X
		Depth	0 FT	0 FT	0 FT	0 FT	0 FT
INORGANICS (ug/g)							
ALUMINUM	15000.0		7050.0	12700.0	7980.0	4740.0	6820.0
ANTIMONY	NA		3.72	19.5	< 1.1	< 1.1	9.67
ARSENIC	21.0		14.0	10.6	9.41	6.88	9.65
BARIUM	42.5		42.8	53.0	307.0	23.2	88.6
BERYLLIUM	.347		2.2	1.19	0.998	< 0.5	1.03
CADMIUM	2.0		1.93	< 0.7	< 0.7	< 0.7	15.5
CALCIUM	1400.0		2270.0	1100.0	1280.0	753.0	8620.0
CHROMIUM	31.0		17.4	21.5	16.1	6.88	22.9
COBALT	NA		9.3	5.14	3.71	3.05	7.36
COPPER	8.39		37.3	11.1	22.6	6.7	54.4
IRON	15000.0		80000.0	13500.0	12900.0	8140.0	23400.0
LEAD	48.4		580.0	300.0	320.0	26.0	1400.0
MAGNESIUM	5600.0		1070.0	2380.0	1590.0	1320.0	1280.0
MANGANESE	300.0		940.0	264.0	223.0	222.0	782.0
MERCURY	.22		< 0.05	0.081	< 0.05	< 0.05	0.077
NICKEL	14.0		22.2	13.2	11.3	9.02	12.7
POTASSIUM	1700.0		315.0	1210.0	755.0	508.0	702.0
SELENIUM	NA		0.382	< 0.25	< 0.25	< 0.25	< 0.25
SILVER	.086		0.733	< 0.58	< 0.25	< 0.25	< 0.25
SODIUM	131.0		218.0	227.0	240.0	187.0	288.0
VANADIUM	28.7		< 3.3	19.0	11.2	7.74	10.9
ZINC	35.5		360.0	74.9	163.0	40.4	9200.0

Notes:

NA = Not Available.

= Value above background level.

TABLE 5-4
INORGANIC ANALYTES IN SURFACE SOIL
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Analyte	Background	Location		41S-92-06X	41D-92-03X	41D-92-04X	41D-92-05X	41D-92-06X
		Depth						
INORGANICS (ug/g)								
ALUMINUM	15000.0			6490.0	7130.0	2620.0	4570.0	3170.0
ARSENIC	21.0			12.2	8.54	4.59	4.67	4.44
BARIUM	42.5			89.2	34.6	19.6	20.8	12.7
BERYLLIUM	.347			0.882	0.68	< 0.5	< 0.5	< 0.5
CALCIUM	1400.0			1650.0	349.0	207.0	240.0	181.0
CHROMIUM	31.0			18.6	10.4	5.83	7.1	< 4.0
COBALT	NA			4.28	3.75	3.04	1.93	2.45
COPPER	8.39			19.7	7.33	4.17	4.79	3.8
IRON	15000.0			16300.0	9440.0	4940.0	5820.0	4890.0
LEAD	48.4			240.0	7.0	1.86	2.36	1.59
MAGNESIUM	5600.0			1990.0	1930.0	960.0	1310.0	955.0
MANGANESE	300.0			251.0	164.0	158.0	56.4	85.4
NICKEL	14.0			14.4	9.36	5.42	6.86	5.24
POTASSIUM	1700.0			668.0	1200.0	633.0	720.0	477.0
SODIUM	131.0			197.0	181.0	152.0	168.0	164.0
VANADIUM	28.7			10.9	9.83	4.75	6.89	4.47
ZINC	35.5			119.0	25.9	17.6	20.7	15.5

NOTES:

TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY

< = LESS THAN DETECTION LIMIT SHOWN

NA = NOT AVAILABLE

= VALUE ABOVE BACKGROUND LEVEL

TABLE 5-5
ANALYTES IN SURFACE WATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SITE ID	SSI		SI		
		41D-93-10X	41D-93-11X	41D-92-01X	41D-92-02X	41D-92-02X
ORGANICS (ug/L)						
1,2-DICHLOROETHANE		1.3	< 0.5	< 0.5	< 0.5	< 0.5
TOLUENE		< 0.5	< 0.5	0.56	< 0.5	< 0.5
INORGANICS (ug/L)						
ALUMINUM		< 141	< 141	8100	1120	250
ARSENIC		3.09	2.77	17	6.72	4.16
BARIUM		< 5	< 5	64.8	16.3	7.65
CALCIUM		2530	2540	7600	4450	3530
CHROMIUM		< 6.02	< 6.02	8.82	< 6.02	< 6.02
COPPER		< 8.09	< 8.09	15.8	< 8.09	< 8.09
IRON		695	555	16400	3030	1510
LEAD		< 1.26	< 1.26	43.9	18.3	2.93
MAGNESIUM		725	770	2170	1060	852
MANGANESE		20.1	18.6	976	215	110
POTASSIUM		< 375	464	2570	1410	545
SODIUM		1670	1740	4260	3510	3290
VANADIUM		< 11	< 11	24.9	< 11	< 11
ZINC		< 21.1	< 21.1	98	< 21.1	< 21.1
OTHER (ug/L)						
ALKALINITY		7000	6000	14000	11000	11000
CHLORIDE		< 2120	< 2120	4610	< 2120	< 2120
NITROGEN BY KJELDAHL METHOD		610	790	3330	1620	1710
PHOSPHATE		21.2	23.1	287	99	149
TOTAL HARDNESS		9800	10400	29200	26000	16600
TOTAL SUSPENDED SOLIDS		38000	6000	362000	30000	32000

Notes:

< = Less than detection limit.

TABLE 5-6
ANALYTES IN SEDIMENT
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SIDE ID	LOW AREA					CRANBERRY POND				
		SSI					SI				
		41D-93-07X	41D-93-08X (DUP)	41D-93-08X	41D-93-09X	41D-93-10X	41D-93-11X	41D-92-01X	41D-92-02X		
ORGANICS (ug/g)											
ACETONE		< 0.017	0.076	< 0.017	< 0.017	0.079	< 0.017	< 0.017	0.028		
CHLOROFORM		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.012	< 0.001		
ACENAPHTHYLENE		< 0.033	< 0.033	< 0.033	0.15	< 0.033	< 0.033	< 0.033	< 0.033		
ANTHRACENE		< 0.033	< 0.033	< 0.033	0.14	< 0.033	< 0.033	< 0.033	< 0.033		
BENZO [A] ANTHRACENE		< 0.17	< 0.17	< 0.17	1.6	< 0.17	< 0.17	< 0.17	< 0.17		
BENZO [A] PYRENE		< 0.25	< 0.25	< 0.25	2.1	< 0.25	< 0.25	< 0.25	< 0.25		
BENZO [B] FLUORANTHENE		< 0.21	< 0.21	< 0.21	2.4	< 0.21	< 0.21	< 0.21	< 0.21		
BENZO [G,H,I] PERYLENE		< 0.25	< 0.25	< 0.25	1.3	< 0.25	< 0.25	< 0.25	< 0.25		
BENZO [K] FLUORANTHENE		< 0.066	< 0.066	< 0.066	0.69	< 0.066	< 0.066	< 0.066	< 0.066		
CHRYSENE		< 0.12	< 0.12	< 0.12	2.4	< 0.12	< 0.12	< 0.12	< 0.12		
DI-N-BUTYL PHTHALATE		< 0.061	< 0.061	0.41	0.51	0.29	< 0.061	< 0.061	< 0.061		
FLUORANTHENE		0.083	< 0.068	0.13	2.8	< 0.068	< 0.068	< 0.068	< 0.068		
INDENO [1,2,3-CD] PYRENE		< 0.29	< 0.29	< 0.29	1.6	< 0.29	< 0.29	< 0.29	< 0.29		
NAPHTHALENE		< 0.037	< 0.037	< 0.037	0.1	< 0.037	< 0.037	< 0.037	< 0.037		
PHENANTHRENE		< 0.033	< 0.033	0.1	0.92	< 0.033	< 0.033	< 0.033	< 0.033		
PYRENE		0.073	< 0.033	0.16	2.6	< 0.033	< 0.033	< 0.033	< 0.033		
4,4-DDD		< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	0.035	0.046	< 0.008		
4,4-DDE		< 0.008	< 0.008	< 0.008	< 0.008	0.015	0.02	0.038	< 0.008		
HEPTACHLOR		< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006		
PCB 1260		0.2	0.182	0.224	0.393	0.217	0.316	< 0.08	< 0.08		
INORGANICS (ug/g)											
ALUMINUM		5630	4830	5060	5090	4360	6380	9430	4220		
ARSENIC		4.34	4.73	4.83	2.3	4.18	4.56	13.5	3.56		
BARIUM		14.4	10	11.3	15.7	13.5	18.1	63.9	19.7		
CALCIUM		345	433	378	345	656	617	1370	427		
CHROMIUM		8.02	6.39	6.9	9.69	< 4.05	< 4.05	< 4.05	6.92		
COBALT		2.08	< 1.42	< 1.42	1.76	< 1.42	< 1.42	< 1.42	< 1.42		
COPPER		5.49	5.97	6.64	5.12	4.08	5.38	13.6	3.31		
IRON		6510	6900	6390	6270	5590	5060	9510	4250		
LEAD		9.4	16	24	27	6.28	22	40	17		
MAGNESIUM		1500	1330	1280	1530	1170	970	1790	1130		
MANGANESE		65.8	82.2	66.5	78.6	56.9	71.5	178	62		
NICKEL		7.29	6.68	6.32	7.21	4.51	5.81	12.2	5.3		
POTASSIUM		586	403	450	470	258	336	1130	377		
SODIUM		286	564	330	544	783	493	609	205		
VANADIUM		8.89	6.88	7.46	8.69	7.32	8.21	19.3	5.28		
ZINC		24.2	25.4	25.9	30.1	19.6	22.6	98.1	18.6		
OTHER (ug/g)											
TOTAL ORGANIC CARBON		2750	3360	5790	8330	22300	27600	22000	8830		

Notes:
 < = Less than detection limit.
 DUP = Duplicate sample.

TABLE 5-7
ANALYTES IN GROUNDWATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: PAL CATIONS/ANIONS (µg/L)	Fort Devens Background Concentrations	ROUND 1			ROUND 2			ROUND 3		
		41D-92-03X	41D-92-04X	41D-92-05X	41D-92-06X	09/25/92 27 MX4101X1	01/07/93 27 MX4101X2	01/07/93 27 MX4101X2	10/15/93 30 MX4101X3	10/15/93 30 MX4101X3
Chloride		NA	NA	NA	NA	2120	2120	NA	NA	NA
Phosphate	1500.0	1500.0	347.0	178.0	158.0	NA	NA	NA	NA	NA
Sulfate	12100.0	< 10000.0	< 10000.0	< 10000.0	< 10000.0	10000	10000	NA	NA	NA
PAL METALS (µg/L)										
Aluminum	6870	53700.0	13800.0	5470.0	4960.0	7000	32600	302	34100	141 F
Antimony	3.03	3.93	< 3.03	< 3.03	< 3.03	4.2	3.03	3.03	3.03	3.84 F
Arsenic	10.5	37.7	8.64	68.0	60.3	38.5	59.2	4.26	28.3	2.54 F
Barium	39.6	199.0	47.0	27.4	22.7	268	228	5	158	3820 F
Beryllium	5	< 5.0	< 5.0	< 5.0	< 5.0	6.06	5	5	5	5 F
Calcium	14700	49800.0	5500.0	2100.0	2180.0	18300	11600	3370	14800	8.09 F
Chromium	14.7	58.5	13.5	< 6.0	< 6.0	88.9	44.4	6.02	62.8	99.8 F
Cobalt	25	< 25.0	< 25.0	< 25.0	< 25.0	58.6	44.4	25	34.1	1.26 F
Copper	8.09	46.1	8.88	< 8.09	< 8.09	93.7	72.9	8.09	57	1460 F
Iron	9100	61100.0	13600.0	25900.0	20700.0	110000	74600	333	48600	58.5 F
Lead	4.25	47.3	10.6	6.72	4.88	44.6	42.2	1.26	32.5	0.243 F
Magnesium	3480	18800.0	3540.0	1620.0	1570.0	26300	17100	1420	13200	34.3 F
Manganese	291	1150.0	239.0	236.0	282.0	893	893	57.4	681	1590 F
Mercury	0.243	< 0.243	< 0.243	< 0.243	< 0.243	0.243	0.243	0.243	0.246	4.6 F
Nickel	34.3	64.5	< 34.3	< 34.3	< 34.3	178	113	34.3	73.6	6680 F
Potassium	2370	12500.0	5190.0	3830.0	3460.0	18800	15100	2610	9890	11 F
Silver	4.6	< 4.6	< 4.6	< 4.6	< 4.6	6.2	4.6	4.6	4.6	4.6 F
Sodium	10800	5610.0	2270.0	2250.0	2140.0	8870	9340	6640	8700	6680 F
Vanadium	11	79.4	20.4	< 11.0	< 11.0	119	102	11	65.6	11 F
Zinc	21.1	144.0	38.0	< 21.1	< 21.1	267	219	21.1	140	21.1 F
PAL PESTICIDES/PCBS										
Endrin		< 0.024	< 0.024	< 0.024	< 0.024	0.0238	0.0381	NA	0.0238	NA
PAL EXPLOSIVES (µg/L)										
Nitroguerin		< 10	< 10	< 10	< 10	10	10	NA	10	NA
PAL SEMIVOLATILE ORGANICS (µg/L)										
*Bis (2-ethylhexyl) Phthalate		< 4.8	< 4.8	< 4.8	< 4.8	4.8	4.8	NA	14	NA
PAL VOLATILE ORGANICS (µg/L)										
1,2-dichloroethylenes (cis And Trans Isomers)		< 0.5	< 0.5	< 0.5	< 0.5	0.5	0.5	NA	0.5	NA
1,1,2,2-tetrachloroethane		< 0.5	< 0.5	< 0.5	< 0.5	170	7.1	NA	33	NA
*Chloroform		< 0.5	< 0.5	< 0.5	< 0.5	9.5	0.5	NA	0.5	NA
Methyl Ethyl Ketone / 2-butanone		< 6.4	< 6.4	< 6.4	< 6.4	6.4	6.4	NA	6.4	NA
Tetrachloroethylene / Tetrachloroethene		< 1.6	< 1.6	< 1.6	< 1.6	10	1.6	NA	2.4	NA
*Toluene		< 0.5	< 0.5	< 0.5	< 0.5	0.5	0.5	NA	0.5	NA
Benzene		< 0.5	< 0.5	< 0.5	< 0.5	0.5	0.5	NA	0.5	NA
Trichloroethylene / Trichloroethene		< 0.5	< 0.5	< 0.5	< 0.5	220	6.4	NA	40	NA
2,4,6-Trinitrotoluene		< 0.63	< 0.63	< 0.63	< 0.63	0.718	0.63	NA	0.63	NA
PAL WATER QUALITY PARAMETERS (µg/L)										
alkalinity		138000.0	14000.0	14000.0	11000.0	27000	39000	NA	NA	NA
nitrite, Nitrate - non Specific		25.5	< 10.0	< 10.0	< 10.0	11000	46.7	NA	NA	NA
nitrogen By Kjeldahl Method		619.0	210.0	1430.0	1810.0	NA	NA	NA	NA	NA
total Dissolved Solids		NA	NA	NA	NA	NA	NA	NA	NA	NA
total Hardness		135000.0	16400.0	9200.0	10600.0	NA	NA	NA	NA	NA
total Suspended Solids		2020000.0	392000.0	180000.0	172000.0	NA	1870000	NA	2180000	NA

TABLE 5-7
ANALYTES IN GROUNDWATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Field Sample Number: (µg/L)	ROUND 4		ROUND 3		ROUND 4		ROUND 3		ROUND 4		ROUND 3		ROUND 4	
	41M-92-01X 01/26/94 MX4101X2	41M-92-01X 01/26/94 MX4101X2	41M-93-02A 10/15/93 MD4102A1	41M-93-02A 10/15/93 MD4102A1	41M-93-02A 01/26/94 MX4102A2	41M-93-02B 10/15/93 MX4102B1	41M-93-02B 10/15/93 MX4102B1	41M-93-02B 01/26/94 MX4102B2	41M-93-02B 01/26/94 MX4102B2	41M-93-02B 01/26/94 MX4102B2	41M-93-02B 01/26/94 MX4102B2	41M-93-02B 01/26/94 MX4102B2	41M-93-02B 01/26/94 MX4102B2	
PAL CATIONS/ANIONS (µg/L)														
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL METALS (µg/L)														
Aluminum	6870	82800	NA	NA	NA	16400	141	48500	141	48500	141	48500	141	
Antimony	3.03	3.84	NA	NA	NA	3.03	3.75	2.95	3.75	2.95	3.75	2.95	3.03	
Arsenic	10.5	56.6	NA	NA	NA	24.2	3.3	78	3.3	78	3.3	78	2.77	
Barium	39.6	461	NA	NA	NA	75.3	5	5	5	5	5	5	5	
Beryllium	5	5	NA	NA	NA	5	5	5	5	5	5	5	5	
Calcium	14700	39200	NA	NA	NA	9170	5170	16400	5170	16400	5170	16400	5520	
Chromium	14.7	149	NA	NA	NA	25.5	6.02	81.5	6.02	81.5	6.02	81.5	6.02	
Cobalt	25	88.9	NA	NA	NA	25	25	42.8	25	42.8	25	42.8	25	
Copper	8.09	147	NA	NA	NA	25.7	8.09	75.7	8.09	75.7	8.09	75.7	8.09	
Iron	9100	110000	NA	NA	NA	24200	119	73200	119	73200	119	73200	166	
Lead	4.25	48.6	NA	NA	NA	11.8	1.26	34.3	1.26	34.3	1.26	34.3	2.49	
Magnesium	3480	30800	NA	NA	NA	7430	2470	17200	2470	17200	2470	17200	2500	
Manganese	291	1820	NA	NA	NA	348	15.4	1210	15.4	1210	15.4	1210	37.6	
Mercury	0.243	0.243	NA	NA	NA	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	
Nickel	34.3	170	NA	NA	NA	34.3	34.3	95.7	34.3	95.7	34.3	95.7	34.3	
Potassium	2370	20500	NA	NA	NA	6120	2020	14400	2020	14400	2020	14400	3100	
Silver	4.6	4.6	NA	NA	NA	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	
Sodium	10800	9710	NA	NA	NA	10000	8560	11100	8560	11100	8560	11100	9480	
Vanadium	11	147	NA	NA	NA	31.7	11	78.9	11	78.9	11	78.9	11	
Zinc	21.1	466	NA	NA	NA	53.1	21.1	326	21.1	326	21.1	326	21.1	
PAL PESTICIDES/PCBS														
Endrin	<	0.0238	NA	NA	NA	<	0.0238	<	0.0238	<	0.0238	<	NA	
PAL EXPLOSIVES (µg/L)														
Nitroglycerin	<	10	NA	NA	NA	<	10	<	10	<	10	<	NA	
PAL SEMIVOLATILE ORGANICS (µg/L)														
*Bis (2-ethylhexyl) Phthalate	<	4.8	NA	NA	NA	<	NA	<	NA	<	NA	<	NA	
PAL VOLATILE ORGANICS (µg/L)														
1,2-dichloroethylenes (cis And Trans Isomers)	<	0.5	NA	NA	NA	<	0.5	<	0.5	<	0.5	<	NA	
1,1,2,2-tetrachloroethane	<	14	NA	NA	NA	<	0.5	<	0.5	<	0.5	<	NA	
*Chloroform	<	0.5	NA	NA	NA	<	0.5	<	0.5	<	0.5	<	NA	
Methylethyl Ketone / 2-butanone	<	6.4	NA	NA	NA	<	83	<	6.4	<	6.4	<	NA	
Tetrachloroethylene / Tetrachloroethene	<	1.6	NA	NA	NA	<	1.6	<	1.6	<	1.6	<	NA	
*Toluene	<	0.5	NA	NA	NA	<	41	<	0.5	<	0.5	<	NA	
Benzene	<	0.5	NA	NA	NA	<	0.5	<	0.5	<	0.5	<	NA	
Trichloroethylene / Trichloroethene	<	11	NA	NA	NA	<	0.5	<	9.1	<	7.9	<	NA	
2,4,6-Trinitrotoluene	<	0.63	NA	NA	NA	<	0.63	<	0.63	<	0.63	<	NA	
PAL WATER QUALITY PARAMETERS (µg/L)														
alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
nitrite, Nitrate-non Specific	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
nitrogen By Kjeldahl Method	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
total Dissolved Solids	110000	110000	NA	NA	NA	NA	NA	96000	NA	96000	NA	96000	NA	
total Hardness	NA	NA	NA	NA	NA	378000	NA	5200000	NA	5200000	NA	5200000	NA	
total Suspended Solids	1800000	1800000	NA	NA	NA	378000	NA	5200000	NA	5200000	NA	5200000	NA	

TABLE 5-7
ANALYTES IN GROUNDWATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Field Sample Number:	Fort Devens Background Concentrations	ROUND 3			ROUND 4			ROUND 5						
		41M-93-03X 10/14/93 39 MX4103X1	41M-93-03X 10/14/93 39 MX4103X1	41M-93-03X 01/20/94 39 MX4103X2	41M-93-03X 01/20/94 39 MX4103X2	41M-93-03X 01/20/94 39 MX4103X2	41M-93-04X 10/14/93 6.5 MX4104X1	41M-93-04X 10/14/93 6.5 MX4104X1						
PAL CATIONS/ANIONS (µg/L)														
Chloride		NA	NA	NA	NA	NA	NA	NA	NA	NA				
Phosphate		NA	NA	NA	NA	NA	NA	NA	NA	NA				
Sulfate		NA	NA	NA	NA	NA	NA	NA	NA	NA				
PAL METALS (µg/L)														
Aluminum	6870	6300	141	F	6330 D	141	DF	22600	141	F	141	F	141	F
Antimony	3.03	3.03	3.38	F	3.03 D	3.03	DF	3.03	3.03	F	3.03	F	3.03	F
Arsenic	10.5	9.4	2.54	F	12.2 D	2.54	DF	83.4	35.2	F	19.5	F	15.4	F
Barium	39.6	30	5	F	30 D	5	DF	158	5	F	12.1	F	12.3	F
Beryllium	5	5	5	F	5 D	5	DF	5	5	F	5	F	5	F
Calcium	14700	6200	3440	F	6290 D	3470	DF	15000	8190	F	2310	F	2420	F
Chromium	14.7	9.61	6.02	F	10.3 D	6.02	DF	35.8	6.02	F	6.02	F	6.02	F
Cobalt	25	25	25	F	25 D	25	DF	25	25	F	25	F	25	F
Copper	8.09	11.9	8.09	F	14 D	8.09	DF	36	8.09	F	8.09	F	8.09	F
Iron	9100	8360	38.8	F	8380 D	117	DF	33500	138	F	5870	F	5640	F
Lead	4.25	4.12	1.26	F	4.12 D	1.26	DF	22.9	1.26	F	1.26	F	1.26	F
Magnesium	3480	3130	1410	F	3180 D	1430	DF	8340	1090	F	500	F	500	F
Manganese	291	177	2.75	F	178 D	3.9	DF	1210	2.75	F	135	F	138	F
Mercury	0.243	0.243	0.243	F	0.243 D	0.243	DF	0.243	0.243	F	0.243	F	0.243	F
Nickel	34.3	34.3	34.3	F	34.3 D	34.3	DF	43.5	34.3	F	34.3	F	34.3	F
Potassium	2370	2690	1130	F	2850 D	1170	DF	8540	2760	F	1560	F	1660	F
Silver	4.6	4.6	4.6	F	4.6 D	4.6	DF	4.6	4.6	F	4.6	F	4.6	F
Sodium	10800	6020	5340	F	6080 D	5410	DF	7910	6840	F	1720	F	1790	F
Vanadium	11	12.7	11	F	17 D	11	DF	36.6	11	F	11	F	11	F
Zinc	21.1	24.6	21.1	F	30.5 D	21.1	DF	146	21.1	F	21.1	F	21.1	F
PAL PESTICIDES/PCBS														
Endrin		0.0238	NA	<	0.0238	NA	<	0.0238	NA	<	0.0238	<	NA	<
PAL EXPLOSIVES (µg/L)														
Nitroglycerin		10	NA	NA	NA	NA		36.5	NA	<	10	<	NA	<
PAL SEMIVOLATILE ORGANICS (µg/L)														
*Bis (2-ethylhexyl) Phthalate		7.5	NA	<	4.8 D	NA		5.5	NA	<	4.8	<	NA	<
PAL VOLATILE ORGANICS (µg/L)														
1,2-dichloroethylenes (cis And Trans Isomers)		1	NA	<	1 D	NA	<	0.5	NA	<	0.5	<	NA	<
1,1,2,2-tetrachloroethane		1	NA	<	1 D	NA	<	0.5	NA	<	0.5	<	NA	<
*Chloroform		1	NA	<	1 D	NA	<	0.5	NA	<	0.5	<	NA	<
Methylethyl Ketone / 2-butanone		10	NA	<	10 D	NA	<	6.4	NA	<	6.4	<	NA	<
Tetrachloroethylene / Tetrachloroethene		1	NA	<	1 D	NA	<	1.6	NA	<	1.6	<	NA	<
*Toluene		1	NA	<	1 D	NA	<	0.7	NA	<	0.6	<	NA	<
Benzene		0.5	NA	<	0.5 D	NA	<	0.5	NA	<	0.5	<	NA	<
Trichloroethylene / Trichloroethene		200	NA	<	200 D	NA	<	150	NA	<	0.5	<	NA	<
2,4,6-Trinitrotoluene		0.63	NA	<	0.63 D	NA	<	0.63	NA	<	0.63	<	NA	<
PAL WATER QUALITY PARAMETERS (µg/L)														
alkalinity		NA	NA	NA	D	NA	NA	NA	NA	NA	NA	NA	NA	NA
nitrite, Nitrate - non Specific		NA	NA	NA	D	NA	NA	NA	NA	NA	NA	NA	NA	NA
nitrogen By Kjeldahl Method		NA	NA	NA	D	NA	NA	NA	NA	<	NA	NA	NA	NA
total Dissolved Solids		NA	NA	NA	D	NA	NA	84000	NA	NA	NA	NA	NA	NA
total Hardness		NA	NA	NA	D	NA	NA	2900000	NA	NA	NA	NA	NA	NA
total Suspended Solids		447000	NA	540000	D	NA	NA	2900000	NA	7000	NA	NA	NA	NA

TABLE 5-7
ANALYTES IN GROUNDWATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Field Sample Number: (µg/L)	Site ID: Sample Date: Depth: Fort Devens Background Concentrations	ROUND 4			ROUND 3			ROUND 4		
		41M-93-04X 01/26/94 6.5	41M-93-04X 01/26/94 6.5	41M-93-04X 01/26/94 6.5	41M-93-05X 10/15/93 6.5	41M-93-05X 01/26/94 6.5	41M-93-05X 01/26/94 6.5	41M-93-05X 01/26/94 6.5	41M-93-05X 01/26/94 6.5	
		MX4104X2	MX4104X2	MX4104X2	MX4105X1	MX4105X2	MX4105X2	MX4105X2		
PAL CATIONS/ANIONS (µg/L)										
Chloride		NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate		NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate		NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL METALS (µg/L)										
Aluminum	6870	2870	141	12900	141	303	22900	141	303	141
Antimony	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Arsenic	10.5	20.1	2.54	24.8	24.8	17.5	43.2	43.2	12.7	12.7
Barium	39.6	20.8	10.5	59.4	59.4	12.2	83.4	83.4	7.3	7.3
Beryllium	5	5	5	5	5	5	5	5	5	5
Calcium	14700	2510	2440	3840	3840	3320	3510	3510	2530	2530
Chromium	14.7	6.12	6.02	14.4	14.4	6.02	31.7	31.7	6.02	6.02
Cobalt	25	25	25	25	25	25	25	25	25	25
Copper	8.09	8.09	8.09	11.9	11.9	8.09	21.9	21.9	8.09	8.09
Iron	9180	6390	1090	23500	23500	8250	35700	35700	7590	7590
Lead	4.25	3.4	1.26	6.18	6.18	1.26	10.7	10.7	1.26	1.26
Magnesium	3480	991	500	3140	3140	500	5230	5230	611	611
Manganese	291	86.1	68	330	330	333	432	432	173	173
Mercury	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
Nickel	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Potassium	2370	1490	1190	3850	3850	1370	5470	5470	1420	1420
Silver	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Sodium	10800	1620	1610	2380	2380	1830	2320	2320	1720	1720
Vanadium	11	11	11	20.9	20.9	11	29.7	29.7	11	11
Zinc	21.1	42.5	36.4	34.2	34.2	21.1	54.4	54.4	25.4	25.4
PAL PESTICIDES/PCBS										
Endrin	<	0.0238	NA	<	0.0238	NA	NA	NA	NA	NA
PAL EXPLOSIVES (µg/L)										
Nitroglycerin	<	10	NA	<	10					
PAL SEMIVOLATILE ORGANICS (µg/L)										
*Bis (2-ethylhexyl) Phthalate	<	4.8	NA	10	NA	NA	<	4.8	NA	NA
PAL VOLATILE ORGANICS (µg/L)										
1,2-dichloroethylenes (cis And Trans Isomers)	<	0.5	NA	<	0.5	NA	<	0.5	NA	NA
1,1,2,2-tetrachloroethane	<	0.5	NA	<	0.5	NA	<	0.5	NA	NA
*Chloroform	<	0.5	NA	<	0.5	NA	<	0.5	NA	NA
Methyl ethyl Ketone / 2-butanone	<	6.4	NA	<	6.4	NA	<	6.4	NA	NA
Tetrachloroethylene / Tetrachloroethene	<	1.6	NA	<	1.6	NA	<	1.6	NA	NA
*Toluene	<	0.6	NA	<	0.6	NA	<	0.6	NA	NA
Benzene	<	0.5	NA	<	0.5	NA	<	0.5	NA	NA
Trichloroethylene / Trichloroethene	<	0.5	NA	<	0.5	NA	<	0.5	NA	NA
2,4,6-Trinitrotoluene	<	0.63	NA	<	0.63	NA	<	0.63	NA	NA
PAL WATER QUALITY PARAMETERS (µg/L)										
alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
nitrite, Nitrate-non Specific	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
nitrogen By Kjeldahl Method	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
total Dissolved Solids	15000	15000	NA	25000	25000	NA	NA	NA	NA	NA
total Hardness	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
total Suspended Solids	57000	57000	NA	350000	350000	NA	700000	700000	NA	NA

TABLE 5-8
SUMMARY OF SOIL BORINGS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS) ¹	TOTAL VOCs BY PID (ppm)	COMMENTS
Site Investigation						
41M-92-01X	36	(1) 0-2 2-4 4-6 6-8 8-10 10-12 12-14 14-16 16-18 18-20 20-22 24-26 26-28 28-30 30-32 32-34 34-36	26-28	SP SW SW-ML ML ML ML ML ML ML ML ML ML SM SM SM SM SM	BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed at 30'
Supplemental Site Investigation						
41M-93-02B	33	0-2 5-7 10-12 15-17 20-22 25-27 30-32	30-32	SP ML ML ML ML ML-SP SM	BKG BKG BKG BKG BKG BKG BKG	Boring completed at 33'
41M-93-02A	8	0-2 5-7	2-4 4-6	SP ML	BKG BKG	Boring completed at 8'
41M-93-03X	45	0-2 5-7 10-12 15-17 20-22 25-27 30-32 35-37 40-42 45-47	45-47	SM SP SP SP ML SP SP SP SP SP SM-SP	BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed at 45'
41M-93-04X	8	0-2 5-7	5-7	SP SP	BKG BKG	Boring completed at 10'
41M-93-05X	10	0-2 5-7	5-7	SP SP	BKG BKG	Boring completed at 10'
Remedial Investigation						
41M-94-02C	50.2	0-2 4-6 9-11 14-16 19-21 24-26 29-31 34-36 39-41 44-46 49-50.2	29-31	SP ML ML ML ML ML SP SP SP SP SP	BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG	Refusal @ 50.2'

TABLE 5-8
SUMMARY OF SOIL BORINGS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS) ¹	TOTAL VOCs BY PID (ppm)	COMMENTS
41M-94-03B	65	0-2 5-7 10-12 15-17 20-22 25-27 30-32 35-37 40-42 45-47 50-52 60-62 65-67		SP SP SP CL ML ML SP SM SP SP SP SP SP	BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed to 67'
41M-94-06X	14	No Samples Collected		SP*	BKG	Boring completed as SA 4122
41M-94-07X	12	0-2 5-7 10-12	5-7	SM SP SM	BKG BKG BKG	Boring completed to 12'
41M-94-08A	31	0-2 4-6 9-11 14-16 19-21 24-26 29-31	24-26	SP SM ML ML ML SM SM	BKG BKG BKG BKG BKG BKG BKG	Boring completed to 31'
41M-94-08B	44	0-2 4-6 9-11 14-16 19-21 24-26 29-31 34-36 39-41 44-46	39-41	SP SM ML ML ML ML SM SM SM SM	BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed to 46'
41M-94-09A	40	0-2 5-7 10-12 15-17 20-22 25-27 30-32 35-37	35-37	SW SW SP SP ML-SP ML-SP SP SW	BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed to 40'
41M-94-09B	55	0-2 5-7 10-12 15-17 20-22 25-27 30-32 35-37 40-42 45-47 50-52 55-57	40-42	SW SW SP SP ML-SP ML-SP SP SP SP SP SP SP	BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed to 57'

TABLE 5-8
SUMMARY OF SOIL BORINGS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS) ¹	TOTAL VOCs BY PID (ppm)	COMMENTS
41M-94-10X	43	0-2 5-7 10-12 15-17 20-22 25-27 30-32 35-37 40-42	40-42	SP-SW SW SP ML ML ML ML SP SP	BKG BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed to 43'
41M-94-11X	47	0-2 4-6 9-11 14-16 19-21 24-26 29-31 34-36 39-41 44-46	34-36	SP SW SP SW-ML ML ML ML SP SP SP	BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed to 47'
41M-94-12X	40	0-2 5-7 10-12 15-17 20-22 25-27 30-32 35-37 40-42	40-42	SP SW SP ML ML ML ML ML ML ML	BKG BKG BKG BKG BKG BKG BKG BKG BKG BKG	Boring completed to 42'
41M-94-13X	29	0-2 4-6 9-11 14-16 19-21 24-26 29-31	19-21	SP ML ML ML ML ML SP	BKG BKG BKG BKG BKG BKG BKG	Boring completed to 31'
41M-94-14X	12	0-2 4-6 10-12	4-6	SP SW SP	BKG BKG BKG	Coring completed at 10'

Notes:

bgs = below ground surface

VOCs = Volatile Organic Compounds

USCS = Unified Soil Classification System

ppm = parts per million

BKG = Background levels of Total VOCs by PID.

PID = Photoionization Detector

¹ USCS from field samples by on-site geologist during sampling. Soil classification made from grainsize distribution analyses may vary from field classification.

TABLE 5-9
ORGANIC COMPOUNDS IN SUBSURFACE SOIL
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	SI	SSI							
		41M-92-01X	41M-93-02B	41M-93-02B	41M-93-02B	41M-93-02B	41M-93-02B	41M-93-03X	41M-93-05X
ORGANICS (ug/g)	26 FT		0 FT	5 FT	25 FT	DUP 25 FT	45 FT	5 FT	5 FT
BIS (2-ETHYLHEXYL) PHTHALATE	NA		< 0.62	< 0.62	1.2	< 0.62	< 0.62	NA	NA
DI-N-BUTYL PHTHALATE	NA		0.4	0.3	30	0.62	30	NA	NA
OTHER (ug/g)									
*TOTAL ORGANIC CARBON	248	NA	NA	NA	700	< 360	659	643	745

Notes:

< = Less than detection limit

TABLE 5-10
INORGANIC ANALYTES IN SUBSURFACE SOIL
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	BACKGROUND	SSI							
		41M-93-02B 0 FT	41M-93-02B 5 FT	41M-93-02B 25 FT	41M-93-02B DUP 25 FT	41M-93-03X 45 FT	41M-93-04X 5 FT	41M-93-05X 5 FT	
INORGANICS (ug/g)									
ALUMINUM	15000.0	14200	37600	6290	6600	4080	NA	NA	
ARSENIC	21.0	14	25	24	18	13	NA	NA	
BARIUM	42.5	80.5	224	29.7	29.3	23.4	NA	NA	
BERYLLIUM	0.347	< 0.5	1.95	< 0.5	< 0.5	< 0.5	NA	NA	
CALCIUM	14000.0	1370	2280	1970	2080	1200	NA	NA	
CHROMIUM	31.0	24.8	70.3	15.6	17.7	11.7	NA	NA	
COBALT	NA	9.78	17	7.09	6.44	5.28	NA	NA	
COPPER	8.39	16.1	40.4	10.8	11.1	7.39	NA	NA	
IRON	15000.0	24100	50300	11700	12400	7900	NA	NA	
LEAD	36.9	9.5	22	6.05	7.93	3.94	NA	NA	
MAGNESIUM	56000.0	5500	12700	2700	2900	2050	NA	NA	
MANGANESE	300.0	392	541	384	188	147	NA	NA	
NICKEL	14.0	19.5	51.5	16.3	16.9	13.1	NA	NA	
POTASSIUM	17000.0	4140	11500	1380	1570	859	NA	NA	
SODIUM	131.0	449	669	458	497	388	NA	NA	
THALLIUM		< 0.5	1.12	< 0.5	< 0.5	< 0.5	NA	NA	
VANADIUM	28.7	33.9	87.7	12.1	12.4	8.28	NA	NA	
ZINC	35.3	66.3	148	28	34.3	22.4	NA	NA	

Notes:

< = Less than.

Shaded values exceed background limits.

TABLE 5-11
SUMMARY OF SCREENED AUGER PROGRAM
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION
FORT DEVENS, MA

EXPLORATION ID	BOTTOM OF BORING DEPTH (Feet bgs)	ANALYTICAL SAMP. DEPTH (Feet bgs)	SOIL TYPE*	COMMENTS
SA4101	42.5	37.5-42.5	Fine Sandy Silt	Well 41M-94-06X installed in Screened Auger Samples collected from boring at various depths.
SA4102	49	40-45	Fine Sandy Silt	
SA4103	40	35.4-40	Fine Sandy Silt	
SA4104	40	30-40	Clayey Silt	
SA4105	40	34-40	Silt/Clay to Sand	
SA4106	39	30-39	Sand	
SA4107	35	30-35	Clay	
SA4108	28	21-28	Silt, Sand, Clay	
SA4109	35	29-35	Silty Sand	
SA4110	19	9-19	Sand to Silty Clay	
SA4111	37	26-36	Sand	
SA4112	38	28-38	Sand	
SA4113	40	30-40	Sand	
SA4114	45	34-44	Sand	
SA4115	29	20.8-29	Silty Clay	
SA4116	40	33-40	Silt	
SA4117	45	41-45	Silt	
SA4118	24	15-24	Silt to Sand	
SA4119	45	34.5-44.5	Silt	
SA4120	38	30-38	Sand, Silt	
SA4121	19	11.5-19	Sand	
SA4122	14	5.8-14	Sand	
SA4123	70	45-50	Silty Clay	
		50-55	Silty Clay	
		55-60	Silty Clay	
		60-65	Silty Clay	
		65-70	Silty Clay	

NOTES:

* = Soil Type classified from cuttings from Hollow Stem Augers flights at depth that sample was collected from.

bgs = below ground surface

TABLE 5-12
SUMMARY OF TEST PIT FINDINGS
AOC 41 - UNAUTHORIZED DUMPING SITE (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	ANALYTICAL SAMPLE DEPTH (Feet bgs)	SOIL TYPE OBSERVED	COMMENTS
41E-94-01X	10	2 4 10	Sand Sand Clay	Only scattered waste on top
41E-94-02X	9.5	2 9.5	Sand Clay	Only scattered waste on top
41E-94-03X	11	2 11	Sand Sand	Only scattered waste on top
41E-94-04X	3	1 3	Fill Sand	Along alignment of metal pipe
41E-94-05X	10	3 5 10	Fill Sand Sand	Metal shelving just below surface
41E-94-06X	10	3.2 9	Sand Sand	
41E-94-07X	10.5	4 10.5	Sandy Gravel Sand	
41E-94-08X	10.5 12 (Second Pit)	4 10.5 12	Sandy Gravel Sand Sand	One excavation was completed to 10 ft bgs, another excavation was completed to 12 ft. bgs just east of the first pit
41E-94-09X	9.5	4 9.5		
41D-92-03X	6	6	Silt	Sump sample for groundwater collection
41D-92-04X	6	6	Silt	Sump sample for groundwater collection
41D-92-05X	3.5	3	Sand	Sump sample for groundwater collection
41D-92-06X	3.5	3	Sand	Sump sample for groundwater collection

NOTES:

bgs = below ground surface

TABLE 5-13
SUMMARY OF TERRAPROBE SAMPLES
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH	TYPE OF SAMPLE	DEPTH OF SAMPLE	COMMENTS
SOIL VAPOR				
SG401	19	VAPOR	5	
		VAPOR	7	
		VAPOR	9	
		VAPOR	11	
		VAPOR	13	
		VAPOR	19	
SG402	5	VAPOR	5	
SG403	5	VAPOR	5	
SG404	5	VAPOR	5	
SG405	20	VAPOR	10	
		VAPOR	15	
		VAPOR	20	
		VAPOR	5	
SG406	5	VAPOR	5	
SG407	5	VAPOR	5	
SG408	5	VAPOR	5	
SG409	5	VAPOR	5	
SG410	5	VAPOR	5	
SG411	5	VAPOR	5	
SG412	5	VAPOR	5	
SG413	5	VAPOR	5	
SG413A	5	VAPOR	5	
SOIL SAMPLES				
TS401	37	SOLID	20	
		SOLID	25	
		SOLID	32	
		SOLID	37	
TS402	37	SOLID	32	
TS403	37	SOLID	37	
		SOLID	32	
		SOLID	37	
TS404	37	SOLID	20	
		SOLID	25	
		SOLID	32	
		SOLID	37	
TS405	37	SOLID	32	
		SOLID	37	

TABLE 5-13
SUMMARY OF TERRAPROBE SAMPLES
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION ID	COMPLETION DEPTH	TYPE OF SAMPLE	DEPTH OF SAMPLE	COMMENTS
SOIL SAMPLES (Cont.)				
TS406	37	SOLID	32	
		SOLID	37	
TS407	37	SOLID	32	
		SOLID	37	
TS410	37	SOLID	32	
		SOLID	37	
TS411	37	SOLID	32	
		SOLID	37	
TS412	37	SOLID	32	
		SOLID	37	
TS413	?	SOLID	?	
TS414	37	SOLID	32	
		SOLID	37	
TS415	37	SOLID	32	
		SOLID	37	
TS416	37	SOLID	32	
		SOLID	37	

TABLE 5-14
SUMMARY OF MONITORING WELL COMPLETION DETAILS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

WELL IDENTIFICATION	SOIL DRILLING METHOD	BEDROCK DRILLING METHOD	MEDIA SCREENED	WELL SCREEN DEPTH (Feet bgs)	WELL SCREEN ELEVATION (Feet MSL)	COMPLETION DEPTH (Feet bgs)	WELL CONSTRUCTION MATERIAL
SITE INVESTIGATION							
41M-92-01X	HOLLOW STEM AUGER	NA	SOIL	25.1-35.1	222.1 - 212.1	36.0	4" ID PVC
SUPPLEMENTAL SITE INVESTIGATION							
41M-93-02A	HOLLOW STEM AUGER	NA	SOIL	3.0-8.0	246.6 - 241.60	8.0	2" ID PVC
41M-93-02B	HOLLOW STEM AUGER	NA	SOIL	22.0-32.0	227.2 - 217.2	33.0	4" ID PVC
41M-93-03X	HOLLOW STEM AUGER	NA	SOIL	34.0-44.0	223.5 - 218.5	45.0	4" ID PVC
41M-93-04X	HOLLOW STEM AUGER	NA	SOIL	4.0-9.0	223.8 - 218.8	10.0	2" ID PVC
41M-93-05X	HOLLOW STEM AUGER	NA	SOIL	4.0-9.0	222.5 - 217.5	10.0	2" ID PVC
REMEDIAL INVESTIGATION							
41M-94-02C	HOLLOW STEM AUGER	NA	SOIL	40.0-50.0	210.3 - 200.3	50.2	4" ID PVC
41M-94-03B	HOLLOW STEM AUGER	NA	SOIL	54.2-64.2	203.1 - 193.1	65.0	4" ID PVC
41M-94-06X	HOLLOW STEM AUGER	NA	SOIL	4.0-14.0	222.5 - 215.5	14.0	4" ID PVC
41M-94-07X	HOLLOW STEM AUGER	NA	SOIL	3.4-7.9	223.1 - 218.6	10.0	4" ID PVC
41M-94-08A	HOLLOW STEM AUGER	NA	SOIL	16.5-26.5	225.7 - 215.7	30.0	4" ID PVC
41M-94-08B	HOLLOW STEM AUGER	NA	SOIL	34.0-44.0	208.5 - 198.5	44.0	4" ID PVC
41M-94-09A	HOLLOW STEM AUGER	NA	SOIL	29.0-39.0	224.0 - 214.0	40.0	4" ID PVC
41M-94-09B	HOLLOW STEM AUGER	NA	SOIL	45.0-55.0	207.5 - 197.5	55.0	4" ID PVC
41M-94-10X	HOLLOW STEM AUGER	NA	SOIL	29.0-39.0	227.8 - 217.8	43.0	4" ID PVC
41M-94-11X	HOLLOW STEM AUGER	NA	SOIL	36.0-46.0	223.8 - 213.8	47.0	4" ID PVC
41M-94-12X	HOLLOW STEM AUGER	NA	SOIL	27.5-37.5	222.2 - 212.2	40.0	4" ID PVC
41M-94-13X	HOLLOW STEM AUGER	NA	SOIL	17.5-27.5	223.5 - 213.5	29.0	4" ID PVC
41M-94-14X	HOLLOW STEM AUGER	NA	SOIL	2.8-7.8	221.6 - 216.6	10.0	4" ID PVC

Notes:

bgs = below ground surface
MSL = Mean Sea Level
NA = Not Applicable
ID = Inside Diameter
PVC = Polyvinyl Chloride

6.0 SITE GEOLOGY AND GROUNDWATER CHARACTERIZATION

The following subsections present the surficial hydrologic, geologic, and hydrogeologic findings and interpretations for AOC 41.

6.1 SURFICIAL HYDROLOGY

The ground surface of AOC 41 faces south and slopes down to New Cranberry Pond, a tributary to the Nashua River. The tributary currently is impounded by a road culvert at the eastern shore of the pond. The waste material at AOC 41 is located 150 feet north of the pond near the toe of the slope. The area is nearly all wooded with the exception of areas occupied by gravel roadways and several cutouts to the waste material or access to explorations. Surface runoff from the waste material would flow downhill towards the low flat area between northern shore of the pond and the toe of the waste material. Surface water and/or groundwater has been observed to collect in this depression and infiltrate into the soils at this location (Figure 6-1).

6.2 GEOLOGY

This subsection presents geologic descriptions of the various formations encountered at AOC 41 and an interpretation of the findings. Figure 6-1 shows the orientation of geologic cross sections. Figures 6-2 and 6-3 present geologic cross sections A-A' and B-B', respectively. Table 6-1 presents the elevation and thickness of significant geologic units encountered at the site.

6.2.1 Regional Surficial Geology

Bedrock was not encountered in any exploration completed at AOC 41, and it is anticipated that bedrock surface could be substantially deeper than 70 feet (the deepest exploration completed at this AOC). Therefore, bedrock geology will not be discussed in this report. The characteristics of the geology and observed contamination at this AOC indicate that explorations deeper than those already completed are not necessary due to the delineation of the groundwater

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contamination from RI data (further discussion will be presented in Subsection 6.3). Therefore, all discussion shall be limited to overburden geology, including discussions of regional geology.

The overburden soils present at the site are similar to soils referenced in the literature by Jahns (1953) and Koteff (1966), and a summary is presented in Subsection 2.2 of this report. Although exact correlation to the literature is not possible, the overburden soils at AOC 41 appear to be similar to the lacustrine (lake-bottom deposits) sediments of the Ayer Lake Stage referenced in the literature. The deposits were the result of the creation of large glacial lake (Lake Nashua), which was formed by possible ice dams of glacial ice stranded in the Nashua River valley during a period of retreating ice. The impoundment of glacial meltwater upstream formed the large lake. As the ice melted, a series of overflows at successively lower elevations created lacustrine depositions within subsequently lower lake levels, giving rise to four separate depositional phases. The Ayer Lake Stage resulted in deposition of lacustrine samples in this area.

Overburden groundwater near these deposits preferentially flows via the coarser grained sediments associated with these clayey silt lacustrine deposits towards local or regional discharge areas (such as the Nashua River). Regional overburden groundwater flow was modeled by ETA and is presented in Section 2.0 and shown in Figure 2-6. An enlargement of Figure 2-5 for the area near AOC 41 is presented in Figure 6-4. Regional groundwater flow is from the site northeast and then east towards the Nashua River. The location of the South Post Water Point (Well D-1) is presented on this figure, however, the model shows non-pumping conditions. It is anticipated that these groundwater flow conditions exist at AOC 41 and contaminant transport would travel correspondingly.

6.2.2 Site-Specific Overburden Geology

This subsection describes native subsurface soils found at AOC 41, excluding descriptions of waste material.

Soil borings drilled at the site (and test pits encountering shallow soils) indicate that the overburden geology consists of (from ground surface downward): Sand, (labeled the "Upper Sand") with little to trace silts and gravels, Clayey Silt (not

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encountered across the entire site), grading to a Fine Sandy Silt, and finally to a Sand (labeled "Lower Sand") (see Figures 6-2 and 6-3).

The upper sand layer appears to consist primarily of oxidized sands with varying amounts of silt, coarse sand and fine gravel. This material is occasionally disturbed, possibly from past installation activities at the site. The upper sand is generally loose and occasionally saturated, either from the shallow water table (near the pond) or from groundwater perched on top of the underlying clayey silt (as in 41M-93-02A). This layer ranges in thickness from 4 to 19 feet bgs (see Figures 6-2 and 6-3).

The clayey silt layer encountered across the central portion of the site is the most significant geological unit at the site because of its grain size and low hydraulic permeabilities compared to the soils encountered above and below this layer. Additional significance of this layer will be presented in the hydrogeology discussion and the Nature and Distribution of Site Contaminants (Section 7.0). The material encountered is a clayey silt with trace fine sand and occasional silty fine sand layers or laminations. The contact between the silt and the overlying upper sand appears to be quite sharp, and is easily recognizable in samples from soil borings. Top of silt elevation contours are presented on Figure 6-5, and are derived from data presented in Table 6-1.

The clayey silt layer ranges in thickness from 7.3 feet (the silt is non-existent in several borings) to 28.5 feet at 41M-94-12X (see Table 6-1 and Figures 6-2 and 6-3). The lateral distribution of the silt is presented in Figure 6-6. The silt most likely is pinched out entirely below the 235 foot elevation contour on Figure 6-4, however the exact location of the termination of the silt is unknown. The silt may have been eroded on the southern extent at the site by surface water. The top of silt elevation contours and the thickness of silt contours are quite steep and silt is not present in any of the explorations south of the 230 to the 235 foot contour line (i.e., 41M-93-04X, 41M-93-05X, 41M-94-06X, 41M-94-07X, and 41M-94-14X). The silt was only approximately 7 feet thick at 41M-94-09B (see Table 6-1; Figure 6-5). It is believed that the silt pinches out north of this location but no borings were completed north of this location. Screened auger boring SA4114, located west northwest of 41M-94-09B, apparently did not encounter silt, however substantiated with split-spoon samples. Several boring logs indicate that one or several silt layers may mark the change.

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The fine sandy silt underlying the clayey silt layer appears to gradationally become coarser with depth. The contact between this layer and the overlying clayey silt layer is often gradational. However, this sandy silt layer appears to be present across the entire site, with perhaps the exception of those locations near New Cranberry Pond. Soils in those explorations (i.e., 41M-93-04X, 41M-93-05X, 41M-94-06X, 41M-94-07X, and 41M-94-14X), are similar in description and appear to be slightly coarser, displaying more structure and sedimentation, and appear to be alluvial deposits.

Only a few samples of the deepest observed overburden layer at the AOC were collected. These samples are from the deepest explorations, 41M-94-02C, 41M-94-03B, and 41M-94-09B (bottom depths of 50.2, 65, and 55 feet bgs, respectively) and possibly in 41M-94-09A in the 35-foot interval samples. These soils are classified as sand, with some or trace amounts of silt and medium to coarse sand. The contact between this lower sand layer and the overlying sandy silt layer is not sharp, and is often gradational.

It should be noted that soil classifications presented in the boring/test pit logs (see Appendix A) were created by an on-site geologist. The visual classifications are made from samples collected from the exploration without the benefit of any mechanical or other type of soil testing. Very often, a sample is visually classified coarser than the results of the same sample submitted for grain size analyses. Visual classifications are usually made by the percentage of different grain size by volume, rather than percentage by weight used in grain size distribution testing. Therefore, the boring logs and USCS classification presented in Table 5-8, Summary of Soil Borings, are based upon visual classifications. The overburden soil descriptions presented above (and on geologic cross sections) are based upon grain size distribution data (see Appendix B) and the visual field observation, and, therefore, the soil descriptions used in this subsection appear to be finer than the corresponding boring logs.

It is uncertain what types of overburden soils may exist beneath the soils encountered, or at which depth bedrock might be encountered. Significant thicknesses of saturated overburden were encountered, and field observations and field analytical data were used to determine that borings had been advanced significantly deep and that deeper explorations were unwarranted.

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6.2.3 Geophysical Surveys

The objectives of the AOC 41 geophysical survey were to delineate the limits of the landfill and provide information on the possible location of the source of the previously detected groundwater contamination. An initial survey effort was performed during the SSI field program in September 1993. Based on information gathered during that field program, an expansion of the original geophysical survey grid at AOC 41 was recommended to further determine potential source areas. The RI geophysical survey was conducted in September 1994.

Two geophysical surveying techniques, magnetometry and terrain conductivity, were selected as the most appropriate methods to meet the objectives of the RI. A rectangular X-Y grid system was established within the survey area in 1993, within which SSI geophysical survey data were collected (see Figure 5-3). During the RI survey, this initial survey grid system was expanded to search for potential contaminant source area(s) beyond the limits of the SSI survey. The combined surveyed area is presented in Figure 6-7. The combined SSI and RI survey areas total approximately 8 acres (500-by-700-foot survey grid).

Both total field and vertical magnetic gradient data were collected in a 10-by-20-foot spaced grid during the magnetometer survey. Both quadrature phase and in-phase measurements were recorded at the same grid stations during the terrain conductivity survey. All four sets of data provide different information on the electrical and magnetic properties in the region being surveyed. A detailed discussion of the geophysical survey methodology and data collection activities are provided in Appendix E.

Because the survey area is adjacent to an active firing range, UXO clearance was deemed necessary prior to the initiation of the geophysical surveys. Before geophysical surveying started, vegetation was removed along survey lines during UXO clearing activities to allow easier access to the grid nodes. During all phases of geophysical surveying, ABB-ES field personnel were escorted by an ABB-ES subcontractor certified to provide UXO services.

Field maps were generated during geophysical survey data collection for the purpose of locating survey stations, cultural landmarks, and natural and man-made

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surface features within the survey area. Compiled sketch maps from the 1993 and 1994 surveys and raw data values are presented in Appendix E.

6.2.3.1 Magnetometer Survey. The magnetometer survey was conducted using a GEM™ gradiometer. The unit consists of a portable microprocessor-based proton precession magnetometer with a pair of proton precession total field magnetic sensors mounted on a vertical survey pole. With the pole held vertically, the magnetometer simultaneously reads each sensor and provides the total field values and automatically calculates the gradient value at that location. The unit is equipped with an electronics console that allows the operator to view and store collected field data in an internal memory.

Total field and vertical magnetic gradient contour maps were generated from the magnetometer data (Figures 6-7 and 6-8, respectively). After eliminating the effects of surface interference caused by surface debris and man-made structures, anomalies were identified on each of the contour maps. Barbed-wire fence lines, a demolished brick kiln, monitoring well protective casings, steel entrance gate, and other cultural features were detected during the magnetometer survey and are clearly observable on the contour maps.

A major magnetic anomaly observed in both surveys coincided with the surface expression of the debris pile. The lateral dimensions of the anomalies suggest that the extent of waste material is coincident with the surface expression of the waste. Results also suggest that the waste consists, at least in part, of ferrous metal (likely the metal debris and steel beer cans observed at the surface). Two other anomalies were noted in the total field contour map (see Figure 6-7). The first, a broad low magnitude anomaly was observed in the Impact Area extending north and south (see Anomaly #1). The other anomaly (Anomaly #2) exhibited less significant magnitudes. The two total field anomalies were observable in the vertical magnetic gradient data, but were not as prominent (see Figure 6-8).

6.2.3.2 Terrain Conductivity Survey. The terrain conductivity survey was conducted using a Geonics™ EM-31 terrain conductivity meter and Polycorder™ data logger. The EM-31 unit consists of a transmitter/receiver array which can simultaneously measure both components of the electromagnetic magnetic field induced by the instrument when it is coupled with the polycorder (digital data logger).

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As with the magnetometer data, quadrature and in-phase terrain conductivity contour maps were generated (Figures 6-9 and 6-10, respectively). On the terrain conductivity contour maps, the debris landfill, and other surface cultural features are clearly observed. The two anomalies identified in magnetometer survey within the impact zone (not attributable to surface interference) did not exhibit strong quadrature phase anomalies (see Figure 6-9). A very broad anomalous conductivity high was observed in the quadrature phase data extending through the middle of the surveyed area, continuously in a nearly east-west trend across the length of the survey area in widths varying from 100 to 250 feet.

No clear correlation between the quadrature phase and in-phase sets was observable, particularly with the large east-west anomaly. Minor anomalies were observed in the in-phase data near the steel gate, along wire fences, and over the two magnetic anomalies in the impact area (see Figure 6-10).

6.2.3.3 Interpretation of Geophysical Surveys. With the exception of the two impact area magnetic anomalies, all other significant anomalies were attributed to surface features mapped during the survey (see Figure 6-10). Because these two impact area anomalies were detected in the magnetometer survey, it was concluded that they were attributed to buried ferrous metallic objects. This finding is supported by the in-phase terrain conductivity results in that this survey is roughly equivalent to a metal detector survey.

Similarly, with the exception of the broad conductivity anomaly observed in the quadrature phase terrain conductivity data, all other significant terrain conductivity anomalies were attributed to surface features. In considering the soil stratigraphy as determined in nearby soil borings, the quadrature phase anomaly is likely attributed to the natural subsurface clayey silt layer mapping its lateral extent. The presence of an abandoned clay brick kiln and evidence of historical excavation activities (a major depression observed near the waste material) supports the contention that significant natural clayey silt layer exists beneath AOC 41 and is the source of the conductivity anomaly.

No major anomalies suggestive of a 55-gallon drum disposal area were observed. With the exception of the two impact zone anomalies mentioned above, no other notable anomalies were observed (see Figure 6-10).

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6.2.4 Site Geology Interpretation Summary

The geology of AOC 41 can be classified in three different layers (from ground surface downward): Sand (Upper Sand), with little to trace silts and gravels, Clayey Silt (not encountered across the entire site), grading to a Sandy Silt and with depth to Sand (Lower Sand). The single most significant geologic feature of the site is the presence of a layer of clayey silt running east to west across the central portion of the site. The clayey silt layer appears to be lake-bottom lacustrine deposits that are associated with the Ayer Lake stage event. This layer is not encountered on the southern-most portions of the site (near New Cranberry Pond) and is relatively thin (approximately 7 feet) on the northern most portion of the site (41M-94-09B). However, this layer's low permeability and potential control of contamination migration are significant in comparison to the other units encountered across the site. The thickness of the clayey silt ranges from 7 to 29 feet, and bedrock or any deep basal overburden units were not encountered. Groundwater is encountered at the bottom or just into the silt layer across the site, as well as in a perched water table on top of the clayey silt layer. Relationship of water levels associated with this silt layer are significant and will be discussed in the following hydrogeology discussion.

6.3 HYDROGEOLOGY

This subsection presents data and interpretations of hydrogeologic conditions at AOC 41. Groundwater levels referred in this subsection are summarized in Table 6-2. Interpretive water table elevation contours based on water level data collected January 31, 1995 and May 9, 1995 are presented in Figures 6-11 and 6-12, respectively (also see Appendix J). Figure 6-13 presents interpretive groundwater flow direction based on deeper potentiometric head measurements. A summary of vertical hydraulic gradients is presented in Table 6-3. Table 6-4 presents a summary of in situ hydraulic conductivity test results for AOC 41 (see Appendix D for further detail).

At AOC 41, monitoring wells have been installed to screen the upper sand, the intermediate clayey silt and sandy silt, and the deeper sand. The following subsections will present and discuss hydrogeologic data from wells screened in all of these geologic media. Due to the variety of hydrogeologic conditions present

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at AOC 41, discussion of the hydrogeology is divided into the following subsections: perched groundwater conditions (upper sand), water table conditions (clayey silt), and deeper groundwater flow conditions (lower sand). Discussion of vertical hydraulic gradients and in-situ hydraulic conductivity test results is also presented.

The regional hydrogeology of Fort Devens is typical of New England glaciated soils and fractured metamorphic bedrock. Overburden and bedrock transmissivities were estimated by ETA (1992) based upon regional work completed by Brackley and Hansen (1977), and upon water-level information from installation-wide monitoring wells and piezometers. Generally, there is a wide range of transmissivities in the overburden soils dependent upon the material encountered. Areas of high transmissivities are present on the Main Post in areas that are occupied by production wells. Overburden soils in the South Post tend to have lower transmissivities, such as the area near AOC 41 (see Figure 2-5). As mentioned in Subsection 6.2, all explorations at AOC 41 were completed in the overburden, and bedrock was not encountered. Therefore, discussion of regional bedrock hydrogeology will not be discussed. The regional groundwater flow as presented in Figure 2-6 has been enlarged to show the anticipated groundwater flow at AOC 41 and is presented in Figure 6-4. As later discussion will summarize, the regional groundwater flow map presents an accurate representation of conditions encountered at and downgradient of AOC 41.

6.3.1 Perched Groundwater Conditions

During SSI drilling operations at AOC 41, isolated pockets of perched groundwater were detected in the upper sand, above the clayey silt. Monitoring well 41M-93-02A was screened above the clayey silt in a significant perched zone. On January 31, 1995, the water level in the well was approximately 2 to 3 feet above the top of the clayey silt. The sole source of this perched water is probably infiltration of precipitation, as the true water table at this location is at the bottom of the clayey silt (41M-93-02B) (see Figure 6-2). Historic water level data collected from 41M-93-02A indicate the presence of perched groundwater during all seasons. Geologic data collected at AOC 41 indicate that the top of the clayey silt is flattest in the vicinity of 41M-93-02A (see Figure 6-4). Water collecting or pooling on top of the clayey silt along this flatter portion and likely flows radially outward, following the top of the clayey silt. The boring log for 41M-94-02C

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indicates the clayey silt beneath 41M-93-02A is not saturated, however, some fraction of the infiltrating precipitation water likely infiltrates into the clayey silt.

6.3.2 Water Table Conditions

The water table across AOC 41 generally occurs within 5 vertical feet of the interpreted interface between the clayey silt and sandy silt beneath AOC 41 (see Figures 6-2 and 6-3). Figures 6-11 and 6-12 present interpretive water table elevation contours for water level measurements taken January 31, 1995 and May 9, 1995, respectively. At the time of both water level measurement rounds, groundwater appeared to flow radially from an area west of the 41M-93-02B. The interpretive contours indicate a water table divide trending east-west, approximately through monitoring well 41M-93-02B. Groundwater flows south and southeastward toward New Cranberry Pond across the southern portion of the site before it enters the deep groundwater flow pattern, and toward the north and northeast across the northern portion of the site.

In general, there is agreement in flow direction between the two sets of water level data. January water levels are higher than those in May, probably due to a below average snowpack and precipitation during the winter of 1994/1995. The modeled regional overburden groundwater flow direction (see Figure 2-6 and 6-4) compares favorably with groundwater flow direction at the water table for the northern portion of the site and in the deep groundwater flow pattern (see Figures 6-11 and 6-12). A discussion of the regional groundwater flow model is presented in Subsection 2.2.8 of this report.

Geologic and hydrogeologic data suggest that New Cranberry Pond is hydraulically connected to the aquifer beneath AOC 41. Boring logs from monitoring wells installed along the northern edge of the pond indicate an absence of the clayey silt (see Figure 6-2), and water level data from these wells fit the interpretive water table contours (see Figures 6-11 and 6-12). In addition, the water level data from the PVC stand pipe located on the northern edge of the pond also fit the interpretive water table contours, further supporting the hydraulic connectivity. A discussion of long-term monitoring of water levels in monitoring wells 41M-92-01X and 41M-93-03X, and the New Cranberry Pond stand pipe is presented in Subsection 6.3.4 of this report.

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Water table horizontal gradients at AOC 41 range from 0.004 to 0.020 feet/foot based on January water levels, and 0.003 to 0.019 feet/foot based on May water levels.

6.3.3 Deeper Groundwater Flow Conditions

During the RI, four monitoring wells (41M-94-02C, 41M-94-03B, 41M-94-08B, and 41M-94-09B) were installed in the lower sand unit, beneath the clayey silt and sandy silt, to assess hydraulic conditions and groundwater chemistry. Figure 6-13 presents water level data from these wells and an interpretive deep groundwater flow direction. The groundwater flow direction is based on the water levels collected from the deep monitoring wells which are aligned in a linear direction. This alignment is not the most advantageous from assessing groundwater flow direction. Groundwater elevations presented on the figure are from water level measurements collected on January 31, 1995 and May 9, 1995. Based on this data from the four wells used (41M-94-02C, 41M-94-03B, 41M-94-08B, and 41M-94-09B), groundwater appears to flow from New Cranberry Pond to the north and east. The interpretive flow direction compares favorably with that derived from the regional groundwater flow model (see Subsection 2.2.8 of this report and Figure 6-4).

As discussed in Subsection 6.3.2, geologic and hydrogeologic data indicate that New Cranberry Pond is hydraulically connected to the aquifer beneath AOC 41, including the lower sand. As a result, groundwater in the lower sand is probably partially derived from New Cranberry Pond, in addition to contributions from groundwater in the clayey silt and sandy silt above. Subsection 6.3.5 assesses vertical hydraulic gradients between the clayey silt/sandy silt, and the lower sand. In addition, water level data from the four wells screened in the lower sand indicate that the water level in New Cranberry Pond is significant in defining the direction of groundwater flow in the lower sand. Analysis of the data indicate that the pond's surface water is discharging to the deeper groundwater aquifer and directing groundwater flow toward the north and east (Nashua River). This analysis is consistent with the direction of modeled regional overburden groundwater flow presented in Figure 6-4.

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The calculated horizontal gradient for the flow in the lower sand is 0.004 feet/foot from 41M-94-08B to 41M-94-09B, assuming a flowline between these two wells. Appendix D contains detailed calculations of horizontal gradients.

6.3.4 Long-Term Water Level Monitoring Results

Long-term water level monitoring was conducted at AOC 41 using electronic pressure transducers and data loggers at the following locations: the PVC stand pipe located on the north shore of New Cranberry Pond, and monitoring wells 41M-92-01X, and 41M-93-03X (see Figure 6-13). The two monitoring wells are screened at the water table at the bottom of the clayey silt and into the sandy silt. Water level data collection was initiated at the three points between April 14 and May 26, 1994, and terminated on December 1, 1994. Figure 6-14 presents a summary plot of the water level data collected from the three monitoring points. The data gathered during this activity is presented in Appendix D-3.

During the period of observation, water levels in New Cranberry Pond remained relatively constant (within approximately 1.5 feet). However, water levels in the two monitoring wells were 2 to 3 feet higher in the spring than in the summer and fall (see Figure 6-14). Expectedly, New Cranberry Pond data indicate relatively quick water level rise, presumably from precipitation and runoff events, followed by longer periods of water level decline. Water level data from the two monitoring wells indicate a delayed reaction to recharge effects, presumably precipitation, which is also expected due to the time delay associated with infiltration of water and/or discharge from New Cranberry Pond to the aquifer. It is unlikely that 41M-92-01X and 41M-93-03X water levels are influenced by changes in the water level of New Cranberry Pond, due to the distance of these wells from the pond (greater than 300 feet) and the transmissivity of the soil in which these monitoring wells are screened. However, it does appear that the surface water elevation in New Cranberry Pond does help cause the localized flow directions as seen in the groundwater flow maps presented in Figures 6-11 and 6-12.

6.3.5 Vertical Groundwater Gradients

Vertical hydraulic gradients have been calculated for well clusters 41M-93-02B, and 41M-94-02C, 41M-93-03X and 41M-94-03B, 41M-94-08A and 41M-94-08B,

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and 41M-94-09A and 41M-94-09B, and are presented in Table 6-3. The data indicate that consistent downward vertical gradients are present from the clayey silt to the lower sand. Vertical gradients range from 0.009 feet/foot between 41M-94-09A and 41M-94-09B, to 0.135 feet/foot between 41M-93-02B and 41M-94-02C. The magnitude of vertical gradients decreases from well cluster 41M-93-02B and 41M-94-02C northeast to well cluster 41M-94-09A and 41M-94-09B. This decrease appears to correlate with the decrease in thickness of the clayey silt and sandy silt in the same direction.

6.3.6 Summary of In-Situ Hydraulic Conductivity Test Results and Estimated Groundwater Flow Velocities

In situ hydraulic conductivity test results are presented in Table 6-4. Estimates of hydraulic conductivities for the clayey silt and sandy silt range from 1.2×10^{-6} cm/sec to 1.0×10^{-5} cm/sec. Assuming an effective porosity of 30 percent, and horizontal gradients ranging from 0.004 to 0.020 feet/foot, estimated groundwater flow velocities at the water table range from 4.5×10^{-5} to 1.9×10^{-3} feet/day.

Hydraulic conductivities for the lower sand range from 7.4×10^{-5} cm/sec to 6.0×10^{-3} cm/sec. An approximate groundwater flow velocity range can be estimated if one assumes a flowline from 41M-94-08B to 41M-94-09B. Assuming an effective porosity of 30 percent, and an estimated horizontal gradient of 0.004 feet/foot, estimated groundwater flow velocities for the lower sand range from 2.8×10^{-3} to 2.5×10^{-1} feet/day.

Calculations of horizontal gradients and groundwater flow velocities are presented in Appendix D-2.

6.3.7 Summary and Interpretation of Hydrogeology at AOC 41

Movement of groundwater at AOC 41 is influenced by a variety of factors, but most importantly, the stratigraphy and the water level in New Cranberry Pond appear to be the major influences. The upper portion clayey silt encountered beneath the site is significant in that it allows for perching of shallow groundwater derived from infiltration and percolation of precipitation. The clayey silt and sandy silt are also responsible for the elevation of the water table above

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potentiometric groundwater levels measured in the lower sand, creating diverging water table groundwater flow directions from an area just west of the well cluster 41M-93-02B and 41M-94-02C. Water table or shallow perched groundwater in the southern portion of the site moves south and east toward New Cranberry Pond, where it apparently enters the groundwater flow pattern of the lower sand at the interface between New Cranberry Pond and the clayey silt unit and flows north-northeast. In addition, a component of the groundwater at the water table flows to the north and northeast (see Figure 6-11 and 6-12). Combining all of this data together, it does not appear that a significant component of groundwater flow discharges to New Cranberry Pond.

In addition, the magnitude of vertical gradients decreases from well cluster 41M-93-02B and 41M-94-02C to the northeast or well cluster 41M-94-09A and 41M-94-09B. This decrease appears to correlate with the decrease in thickness of the clayey silt and sandy silt in the same direction.

The water level in New Cranberry Pond is significant in defining the direction of groundwater flow in the lower sand. Analysis of the data indicate that the pond is recharging the aquifer and helping to direct local groundwater flow in the lower sand toward the north and east (see Figure 6-13). This analysis is consistent with the modeled overburden groundwater flow direction presented in ETA's regional groundwater flow model (see Figure 6-4). The regional groundwater flow model also indicates that to the northeast of well cluster 41M-94-09A and 41M-94-09B, overburden groundwater flow turns to the east and discharges to the Nashua River.

In summary, groundwater flow at the site is in agreement with the regional groundwater flow presented on Figure 6-4. Existing monitoring well water-level elevation data concur with the regional flow direction and it is anticipated that groundwater flow (and therefore any contaminant transport, if any) would be towards the east and discharge to the Nashua River.

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MONITORING WELL

41M-94-03X

W
SA4123

SCREENED AUGER BORING
(WATER ONLY)

SA4122

SCREENED AUGER BORING
(WATER AND SOIL)

41E-94-02X

TEST PIT

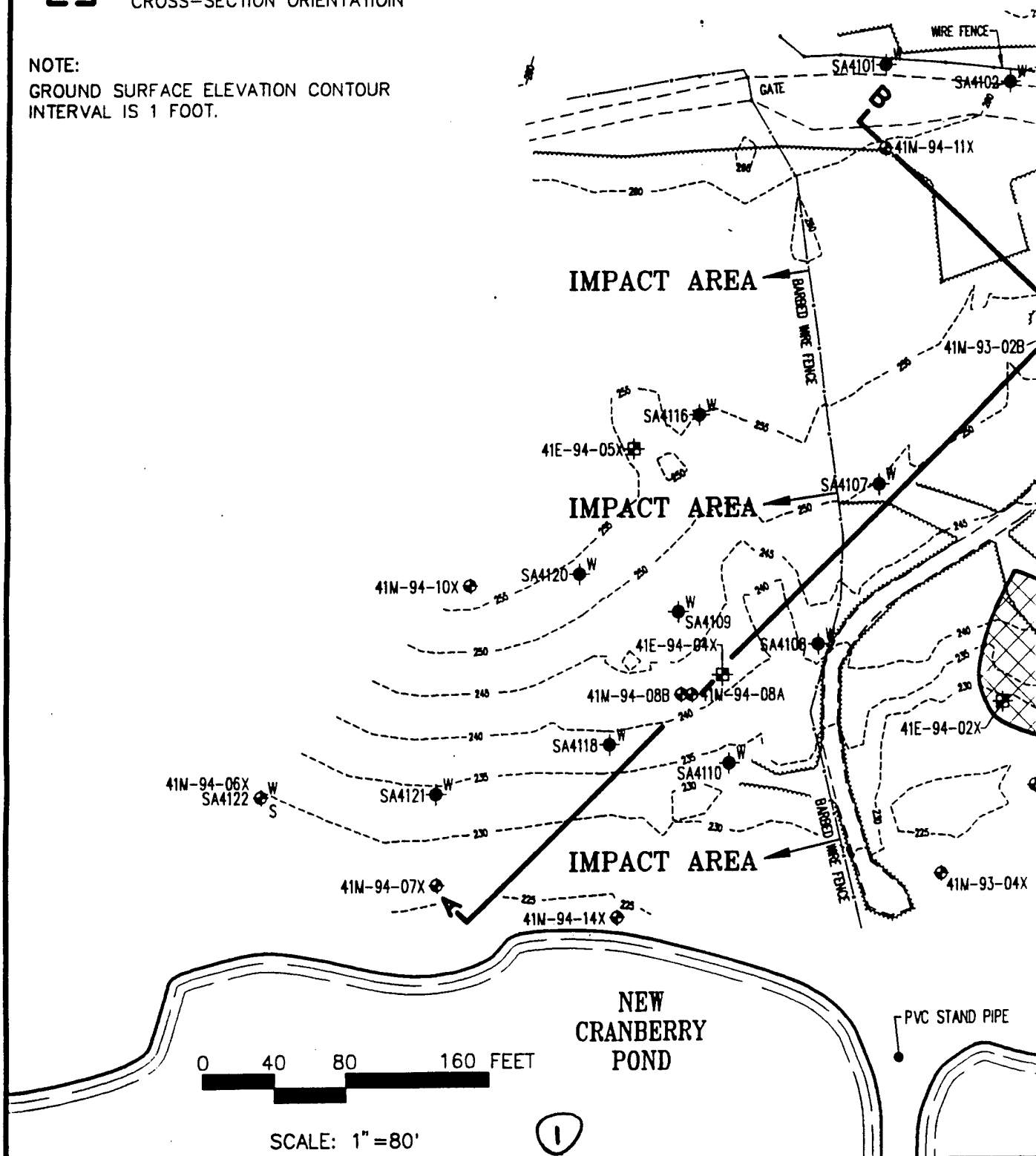
AA

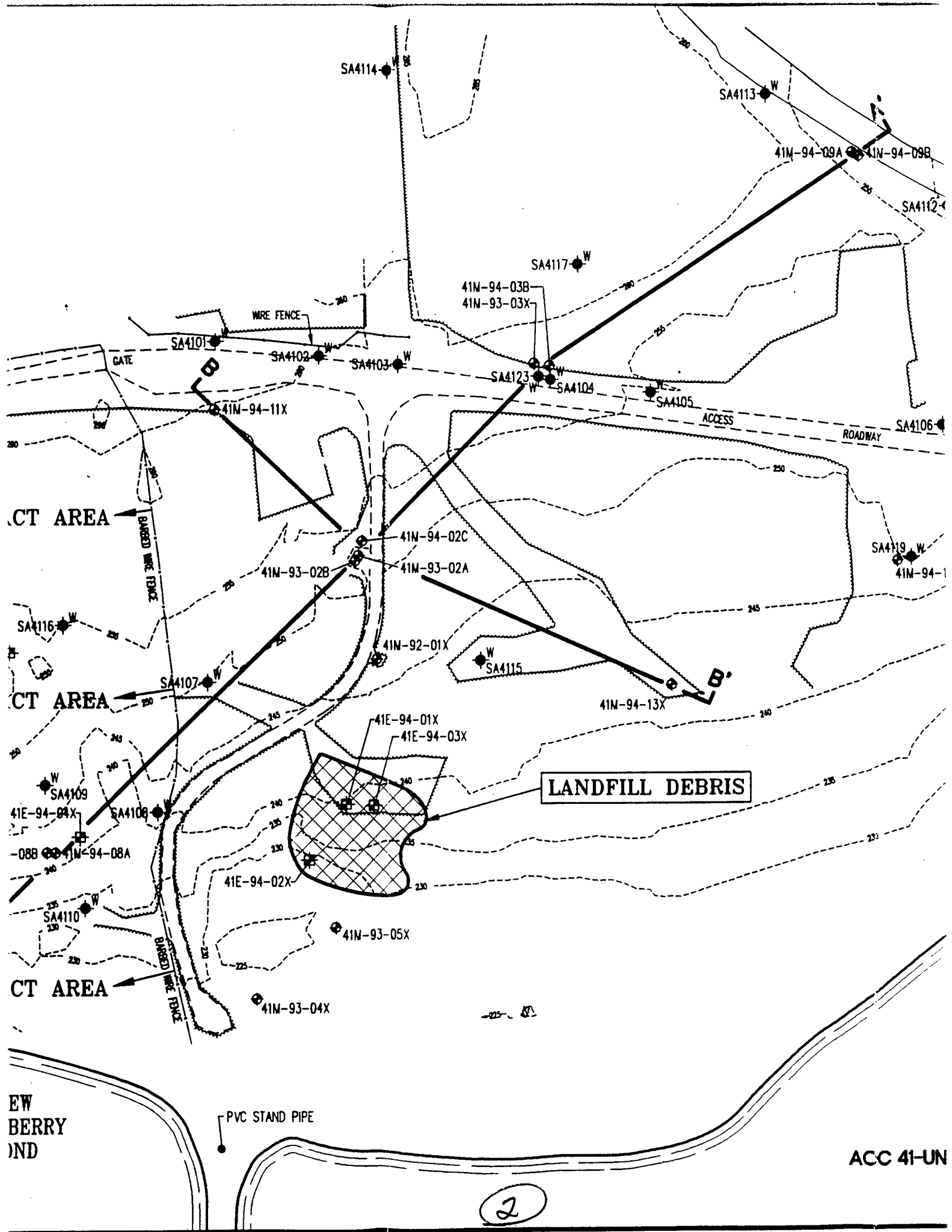
TREELINE

CROSS-SECTION ORIENTATION

NOTE:

GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 1 FOOT.





CT AREA

CT AREA

CT AREA

LANDFILL DEBRIS

EW
BERRY
ND

ACC 41-UN

2

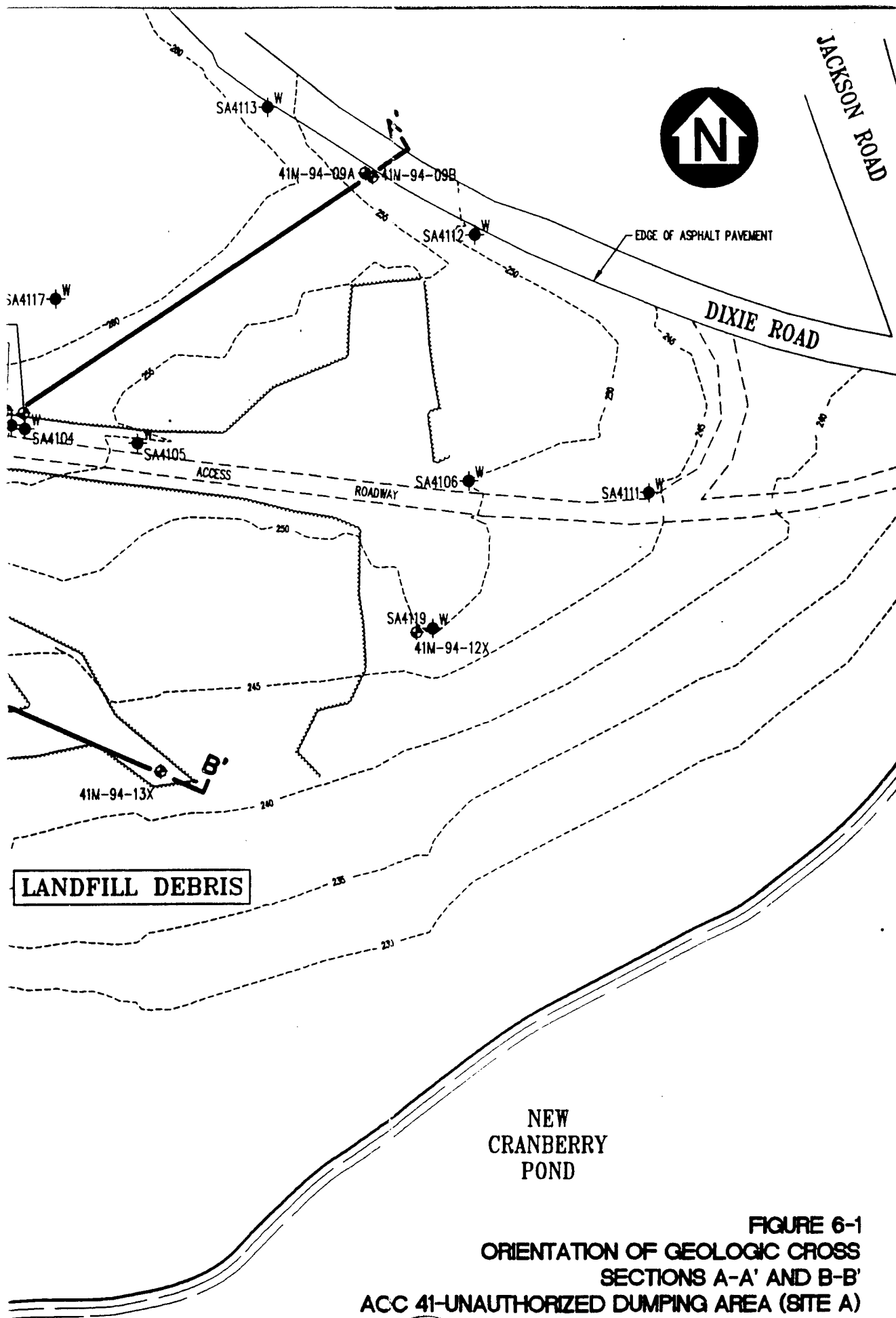
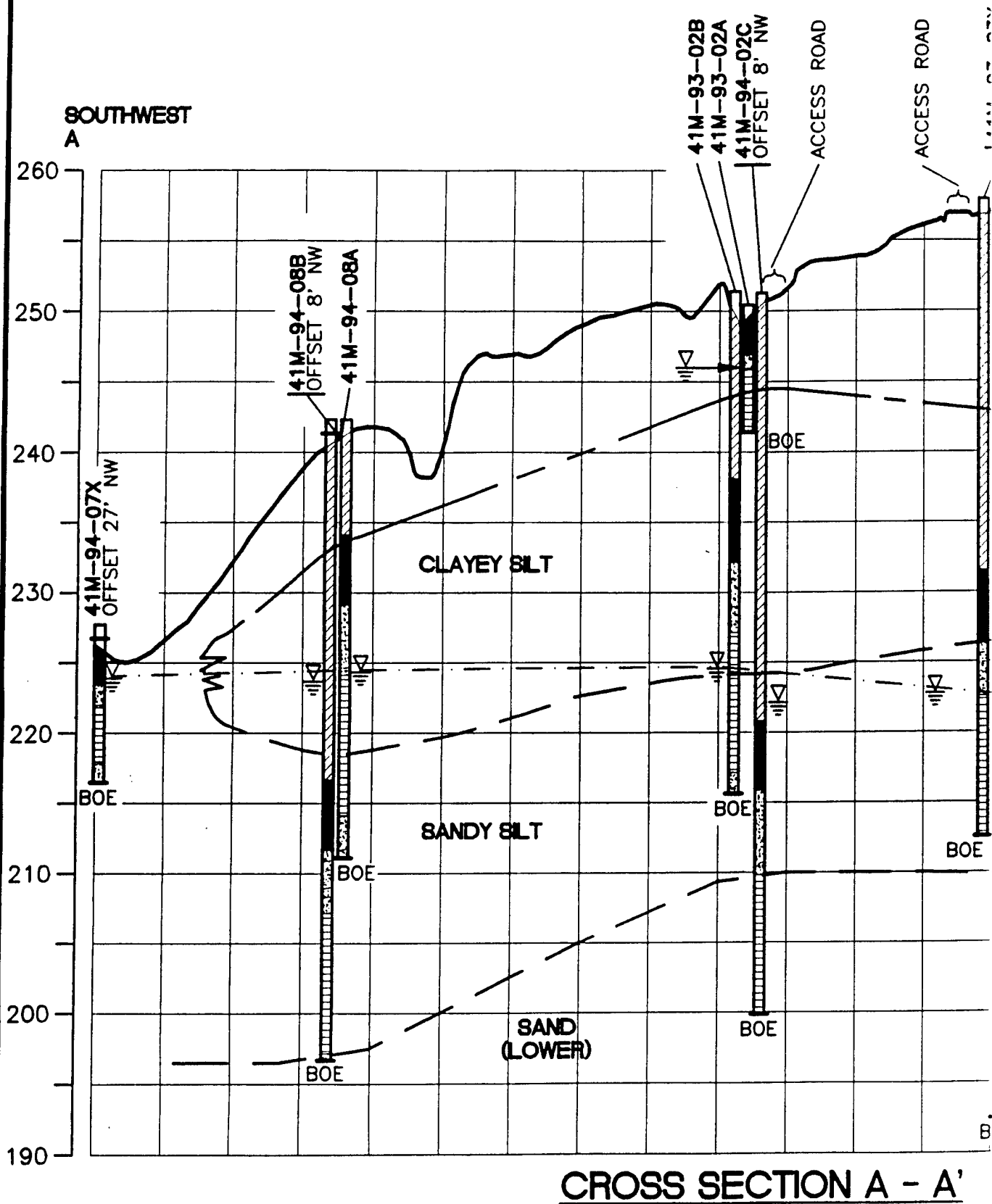
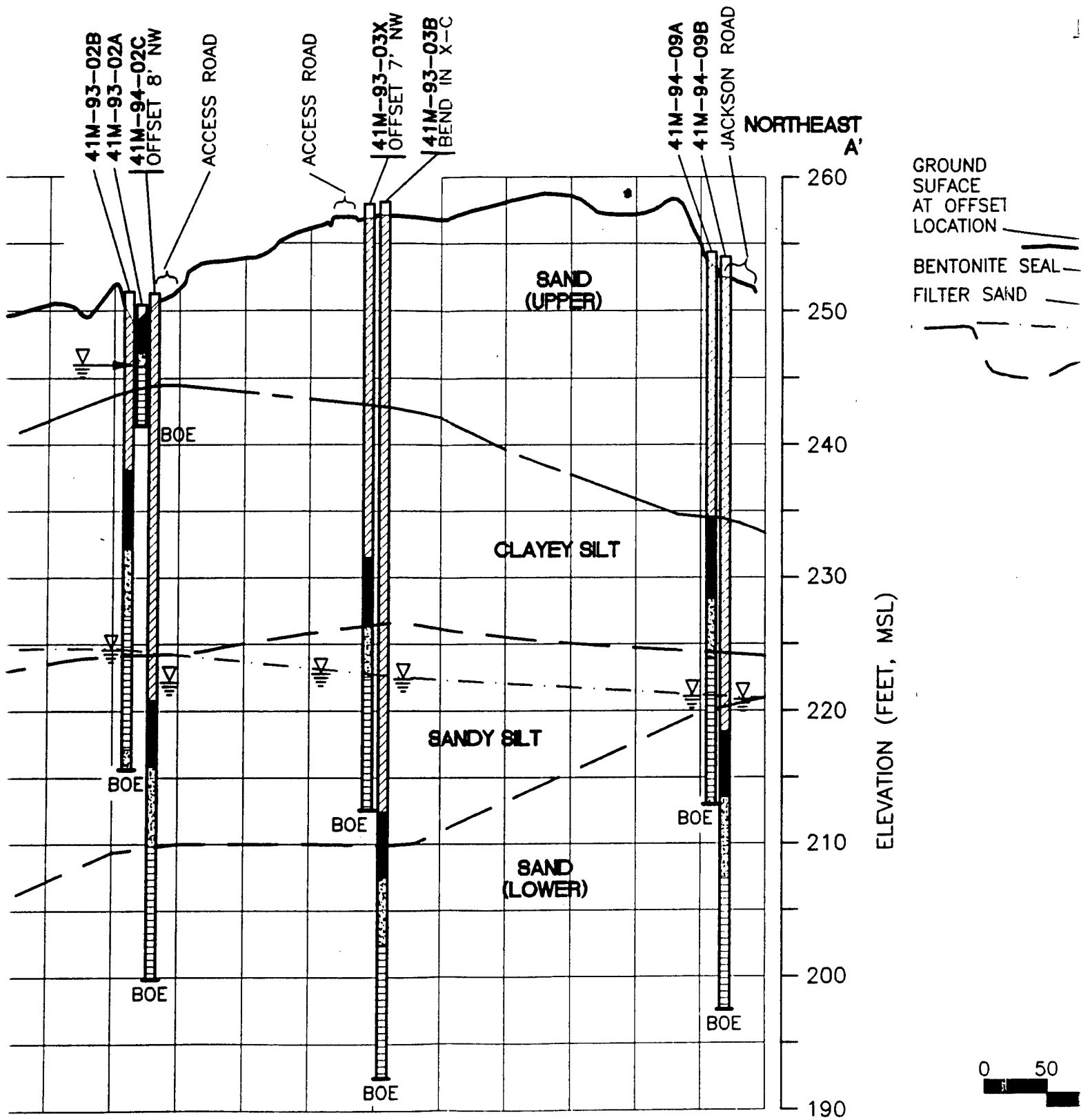


FIGURE 6-1
ORIENTATION OF GEOLOGIC CROSS
SECTIONS A-A' AND B-B'
ACC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

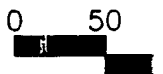


NOTES:

1. FOR ORIENTATION OF CROSS SECTION SEE FIGURE 6-1.
2. GEOLOGIC CONDITIONS BETWEEN WELLS ARE AN INTERPRETATION OF AVAILABLE DATA. ACTUAL CONDITIONS MAY VARY.

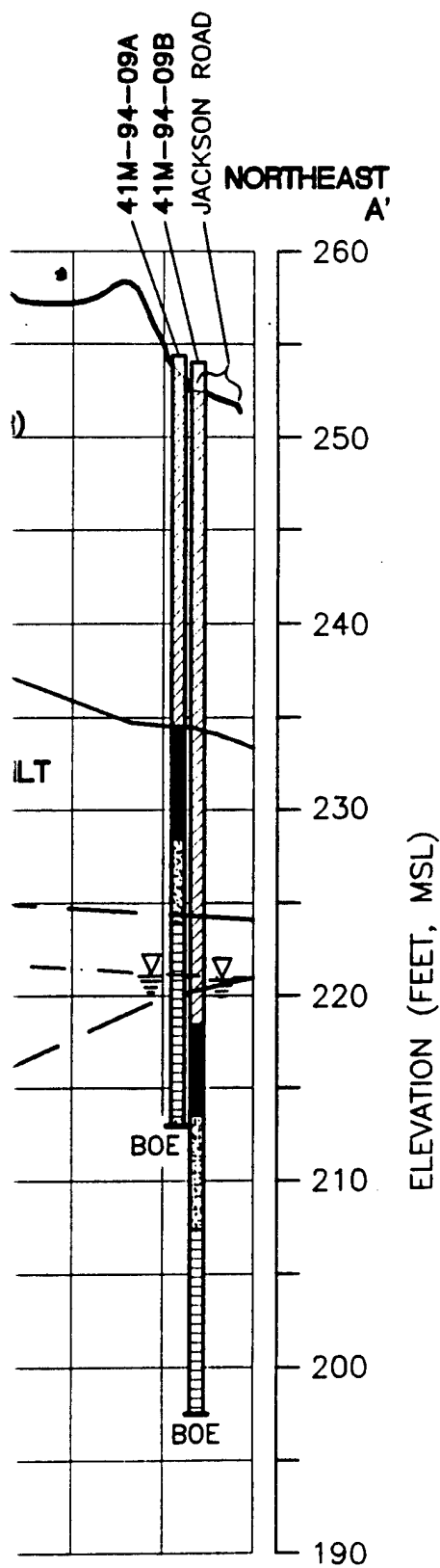


CROSS SECTION A - A'

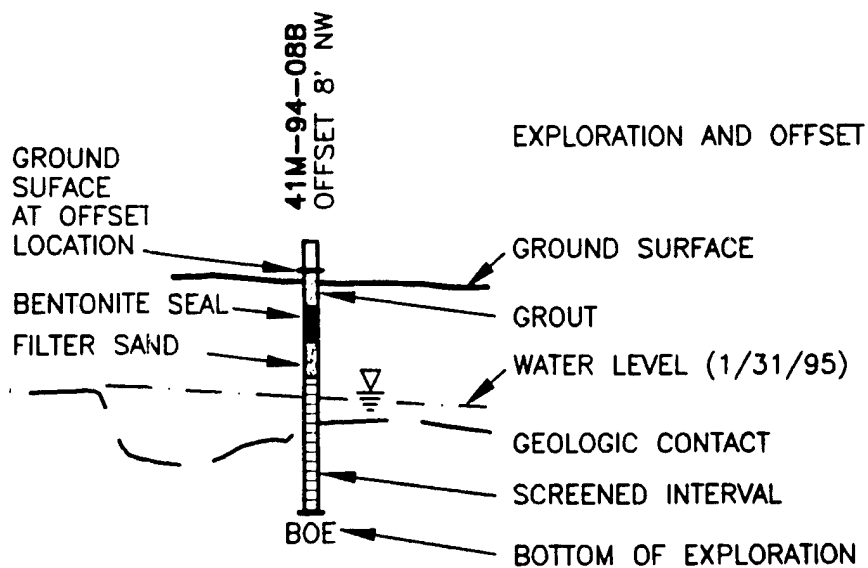


HORIZONTAL
VERTICAL
VERTICAL EX.

INTERPRET
AOC 41-UN



LEGEND

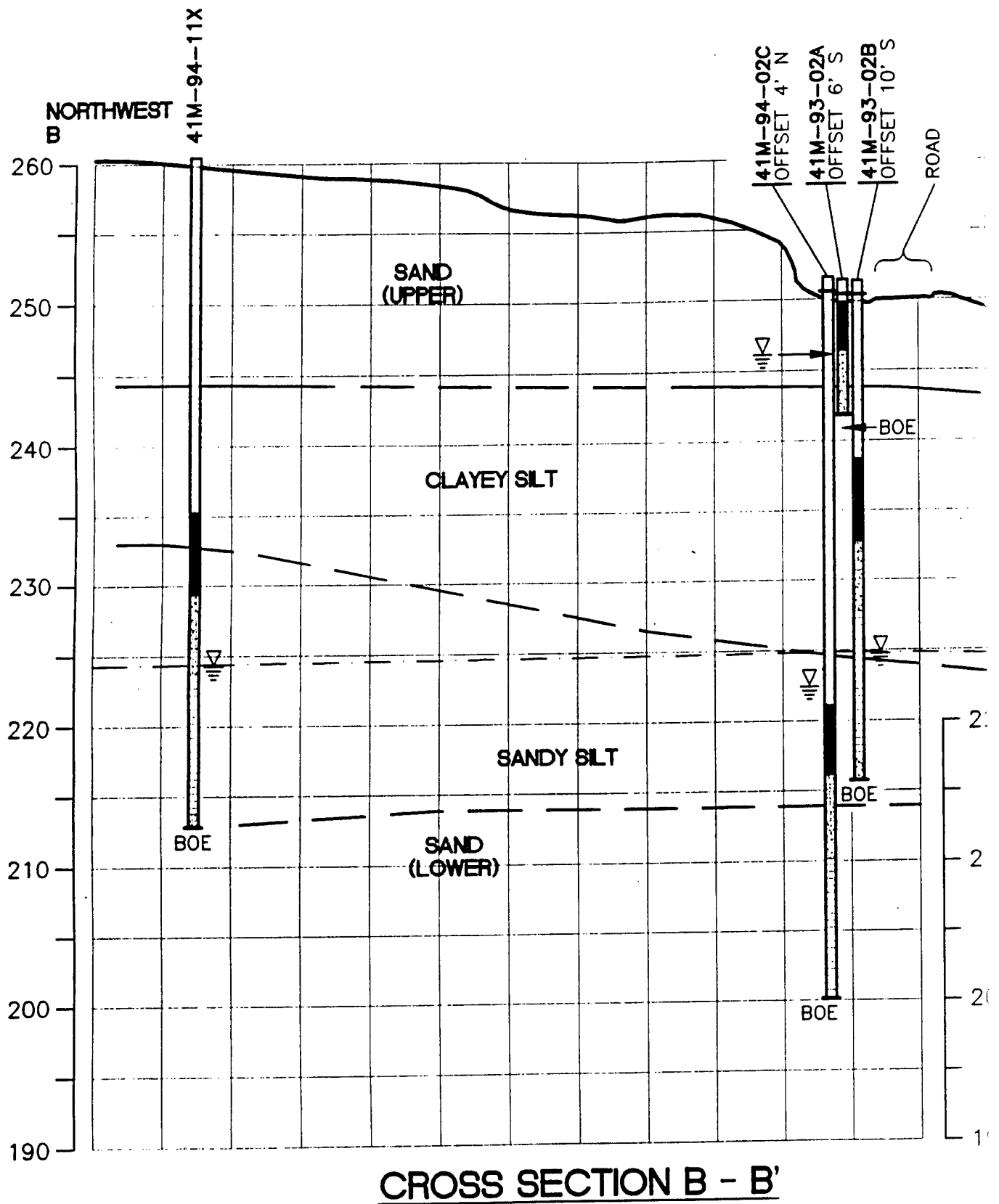


0 50 100 200 FEET

HORIZONTAL SCALE: 1"=100'
VERTICAL SCALE: 1"=10'
VERTICAL EXAGGERATION: 10:1

3

FIGURE 6-2
INTERPRETIVE GEOLOGIC CROSS-SECTION A-A'
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA



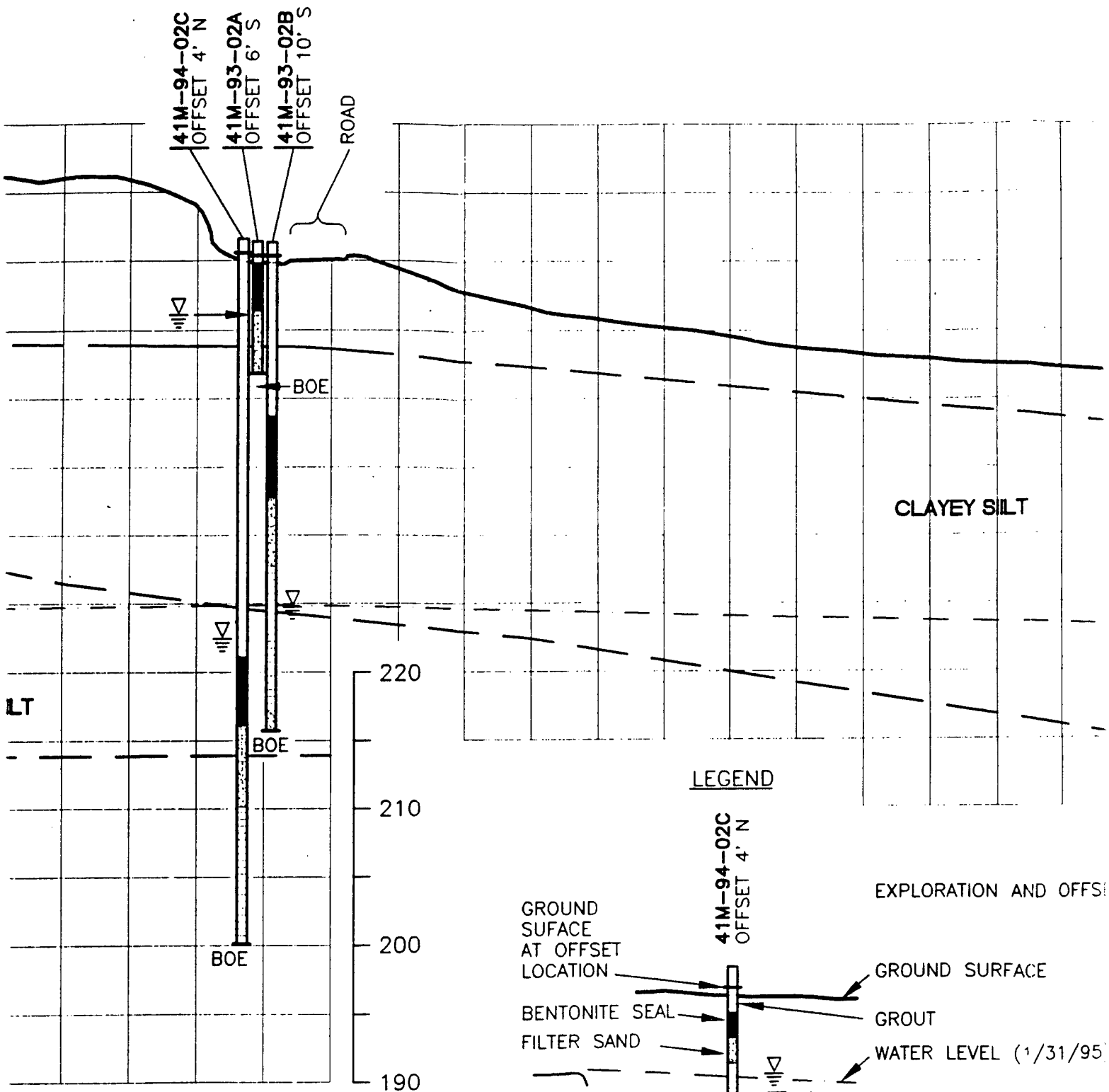
NOTES:

1. FOR ORIENTATION OF CROSS SECTION SEE FIGURE 6-1.
2. GEOLOGIC CONDITIONS BETWEEN WELLS ARE AN INTERPRETATION OF AVAILABLE DATA. ACTUAL CONDITIONS MAY VARY.

0 15

HORIZONTAL
VERTICAL
VERTICAL E





TION B - B'

0 15 30 60 FEET

HORIZONTAL SCALE: 1"=30'

VERTICAL SCALE: 1"=10'

VERTICAL EXAGGERATION: 3:1

INTERPRETATION
ACC 41-UN

2

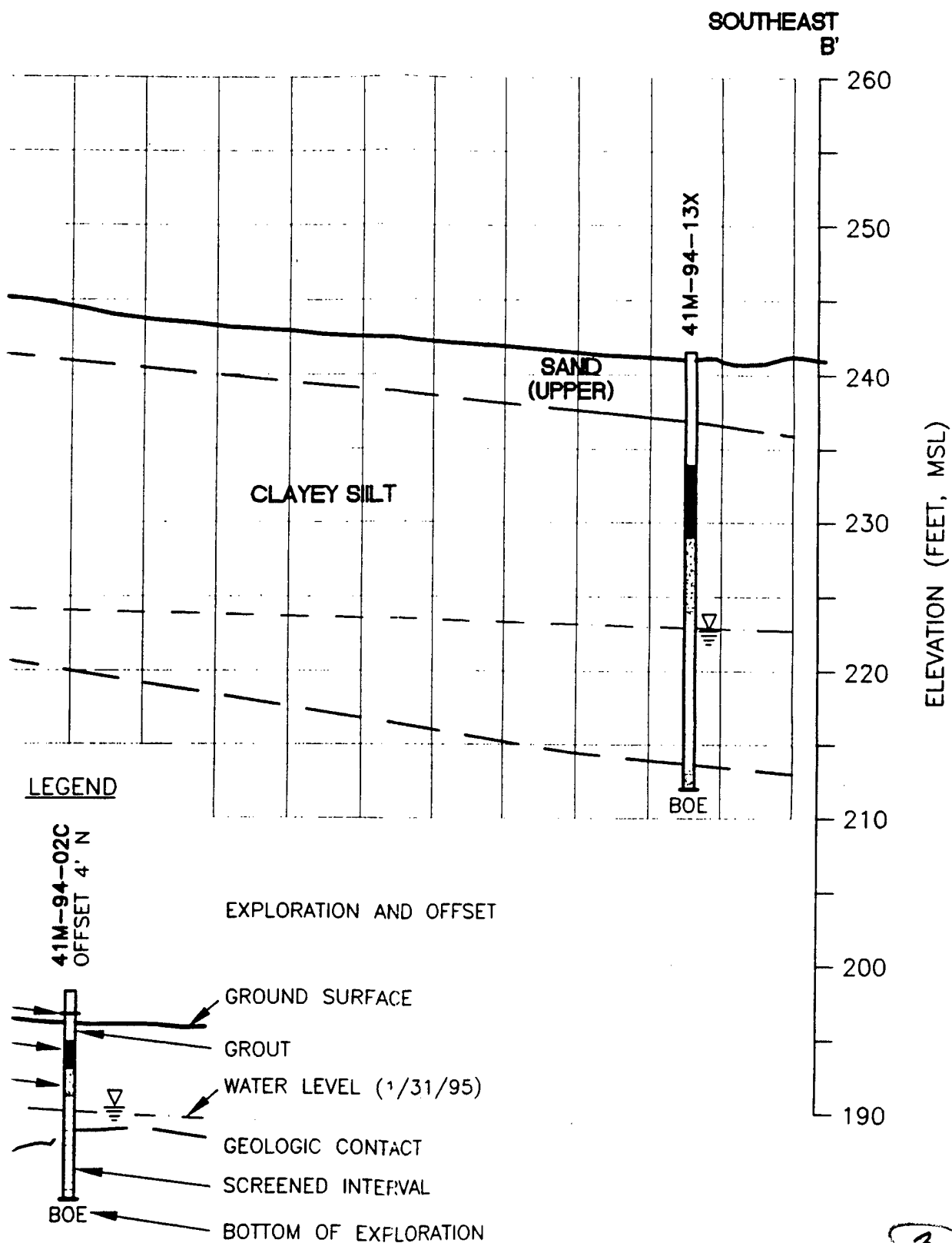
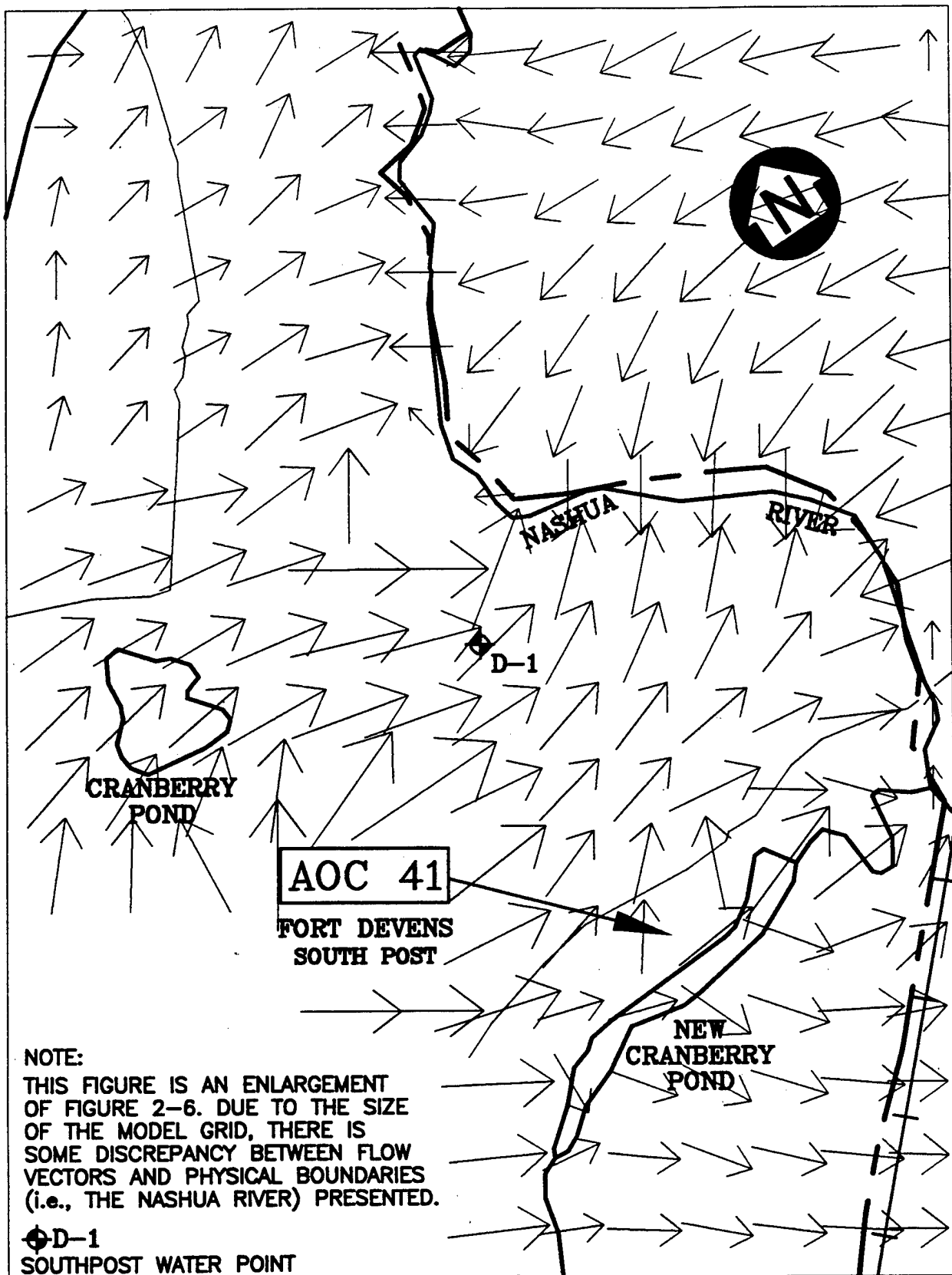


FIGURE 6-3
INTERPRETIVE GEOLOGIC CROSS-SECTION B-B'
ACC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA



SOURCE:
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA,
ETA, INC. OCTOBER 30, 1992.

↗ ↘ ↗ ↘ ↗ ↘
GROUNDWATER FLOW VECTORS





0 500 1000 2000 FEET

SCALE: 1"=1000'

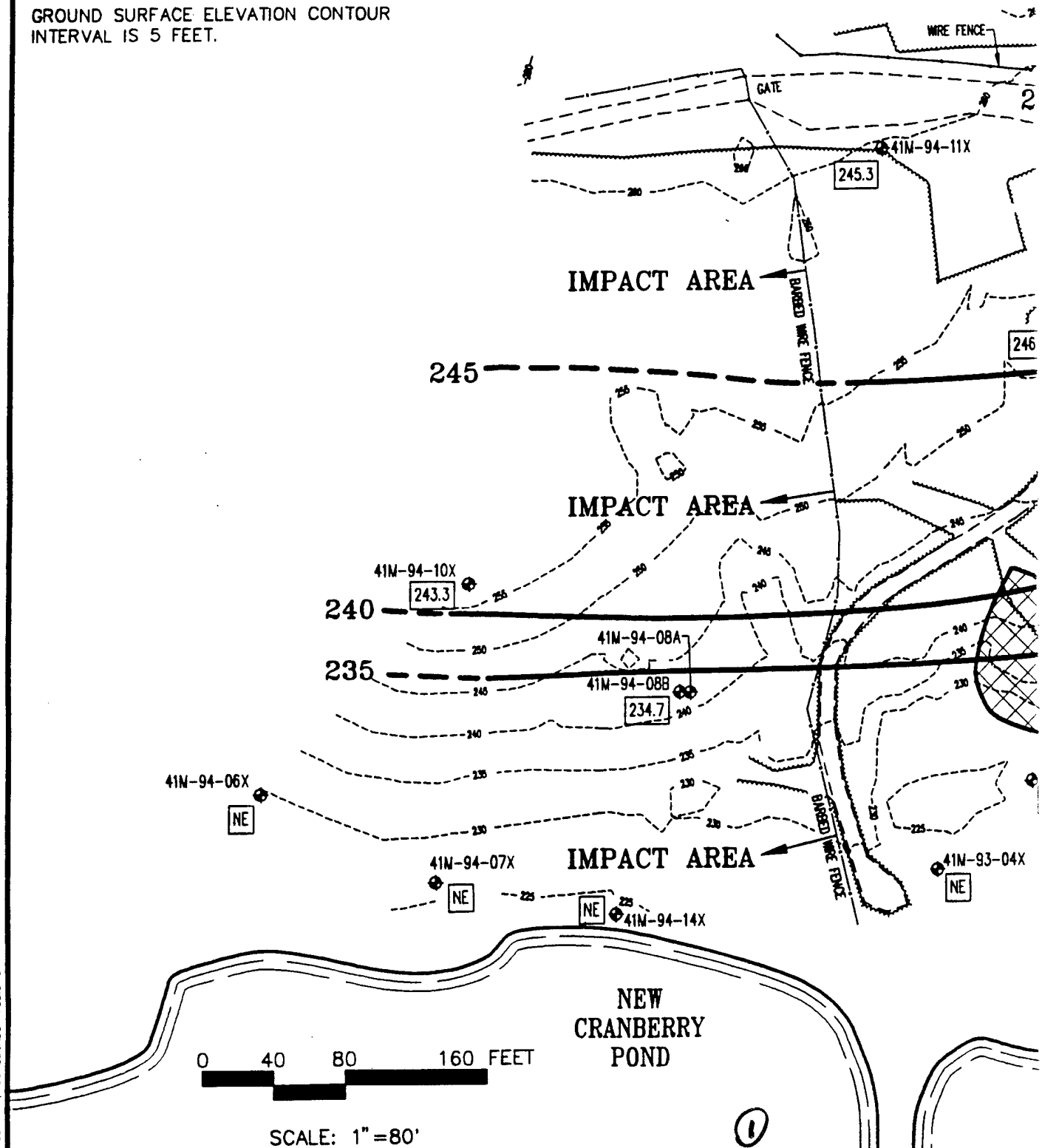
FIGURE 6-4
AOC 41 MODELED OVERBURDEN
GROUNDWATER FLOW MAP
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

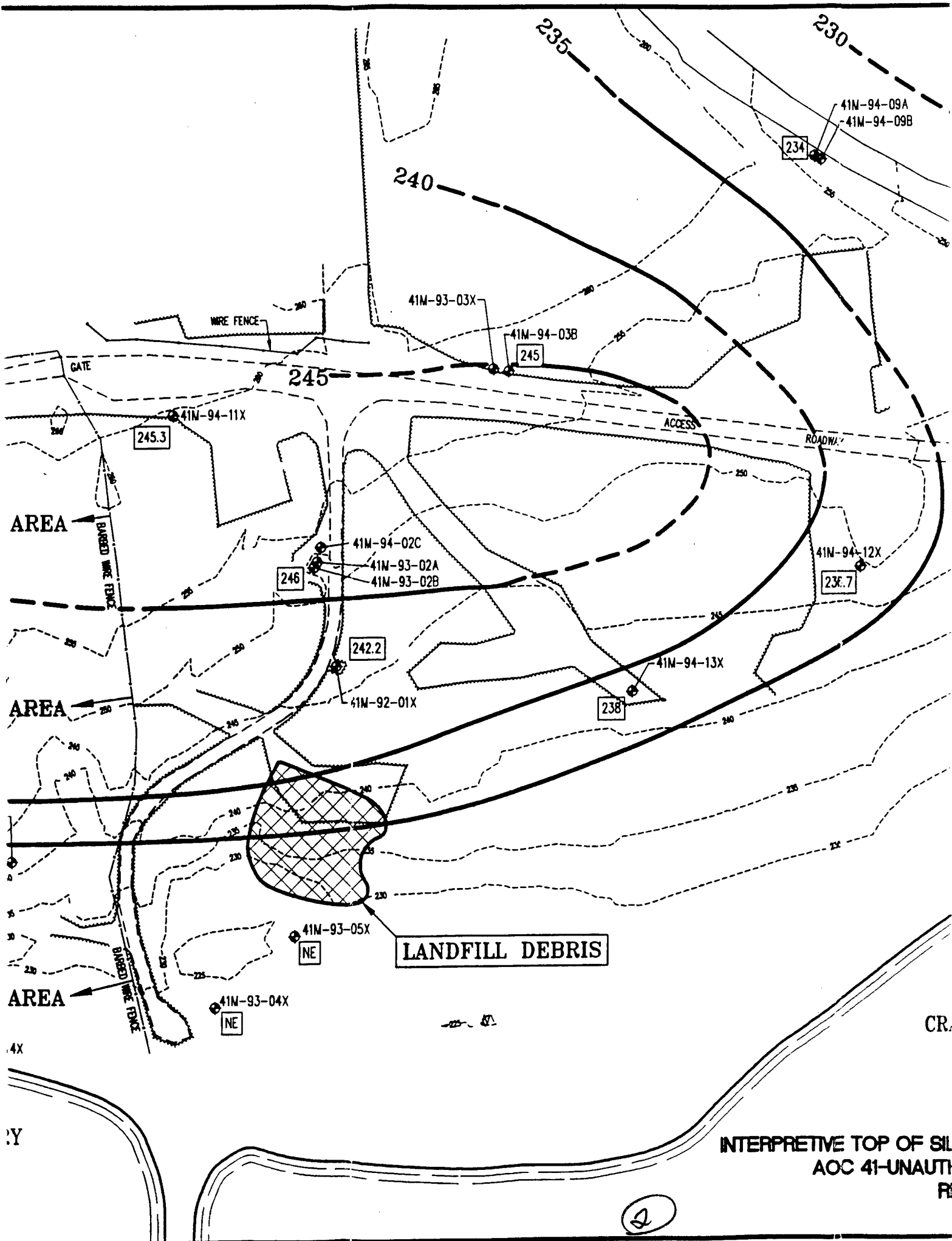
ABB Environmental Services, Inc.

LEGEND

- 
 MONITORING WELL
 41N-94-03X
- 
 TREELINE
- 245 ——— INTERPRETIVE TOP OF SILT
 LAYER ELEVATION CONTOUR
- 
 ELEVATION TOP OF SILT
 AT WELL LOCATION
- 
 NOT ENCOUNTERED

NOTE:
 GROUND SURFACE ELEVATION CONTOUR
 INTERVAL IS 5 FEET.





LANDFILL DEBRIS

INTERPRETIVE TOP OF SIL
AOC 41-UNAUTI
R

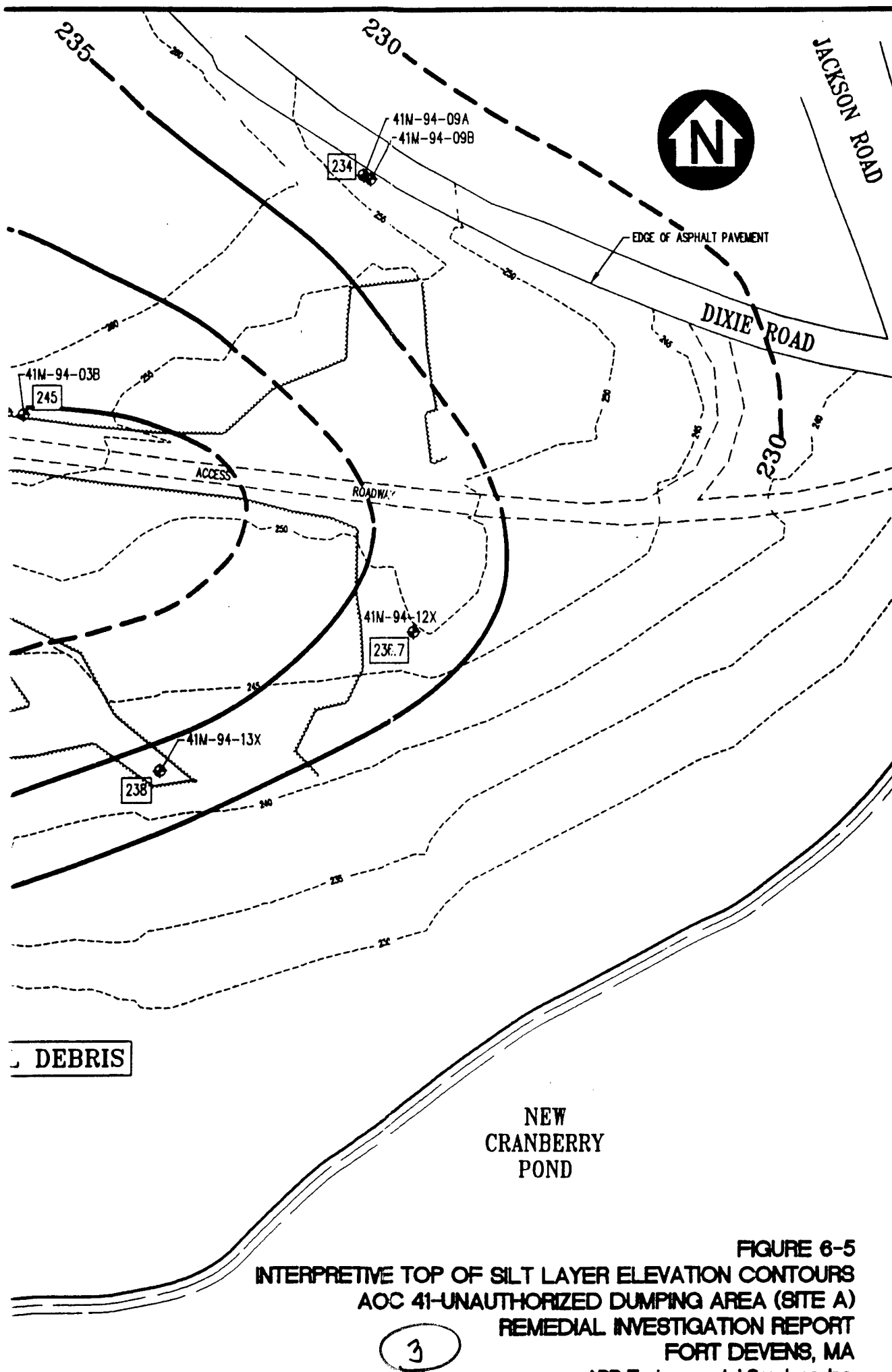





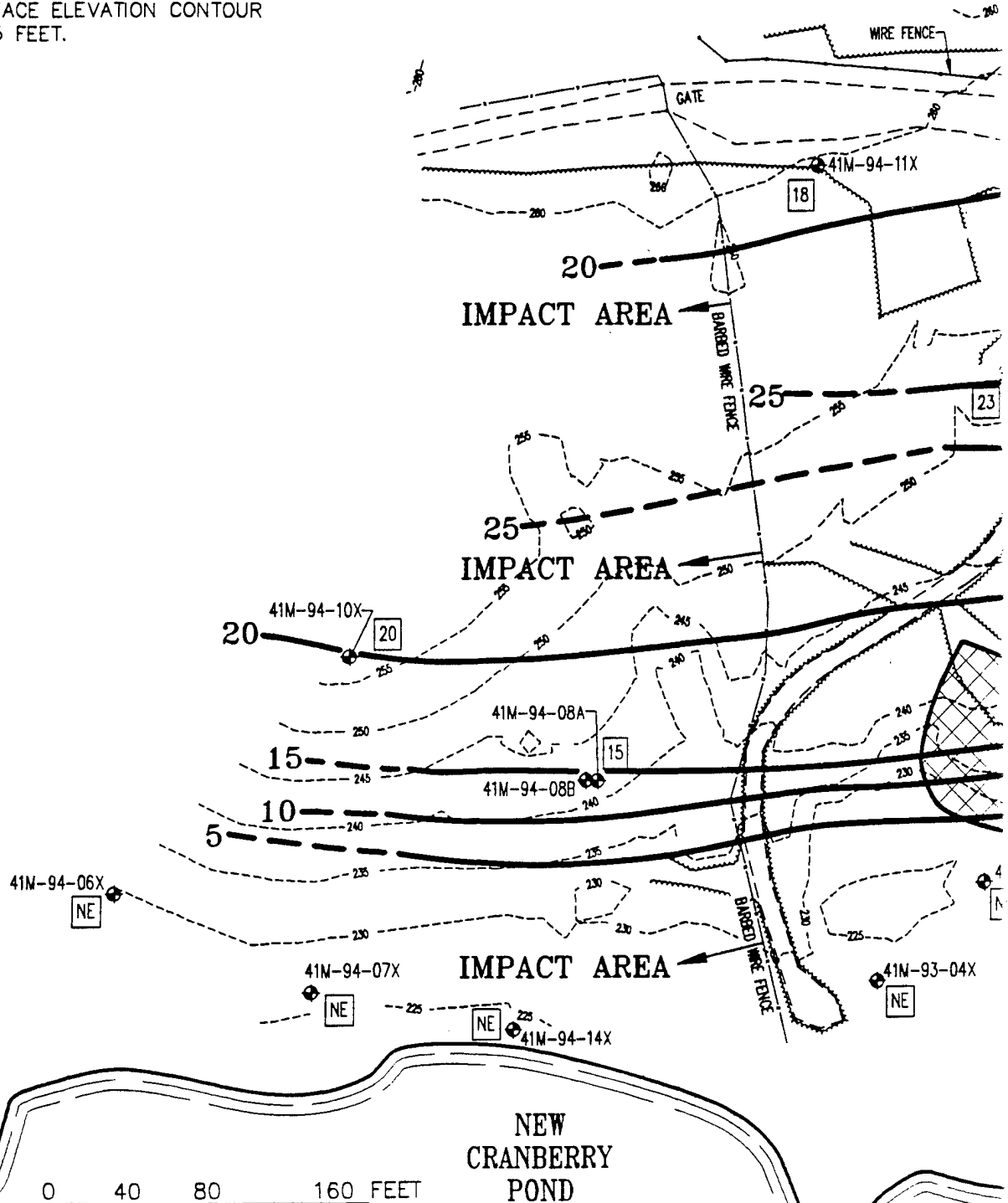


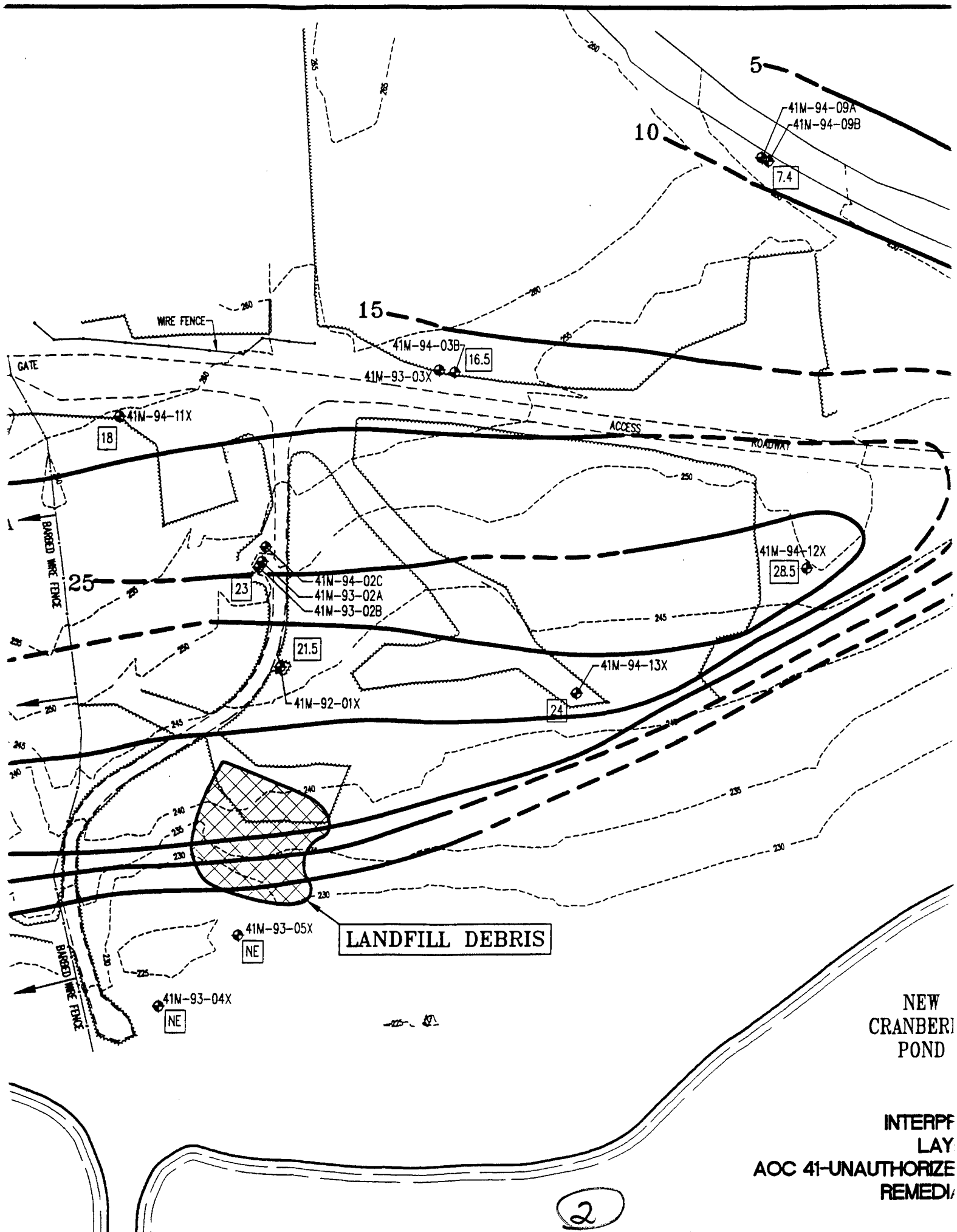
FIGURE 6-5
INTERPRETIVE TOP OF SILT LAYER ELEVATION CONTOURS
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

LEGEND

-  MONITORING WELL
 41M-94-03X
-  TREELINE
- 15  INTERPRETIVE THICKNESS OF SILT LAYER
-  THICKNESS OF SILT AT WELL LOCATION
-  NOT ENCOUNTERED

NOTE:
GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.





NEW
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POND

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LAY
AOC 41-UNAUTHORIZED
REMEDIAL

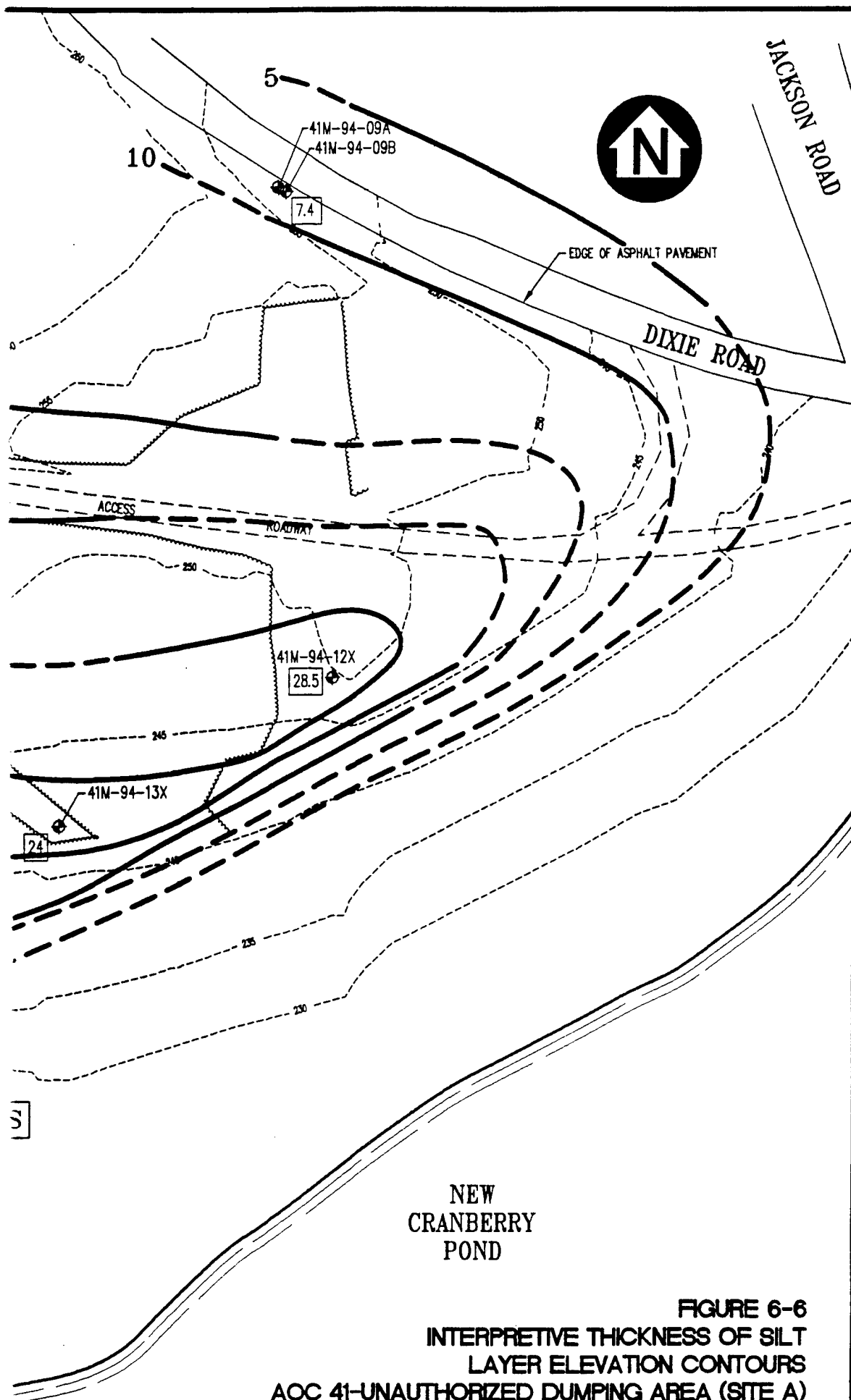





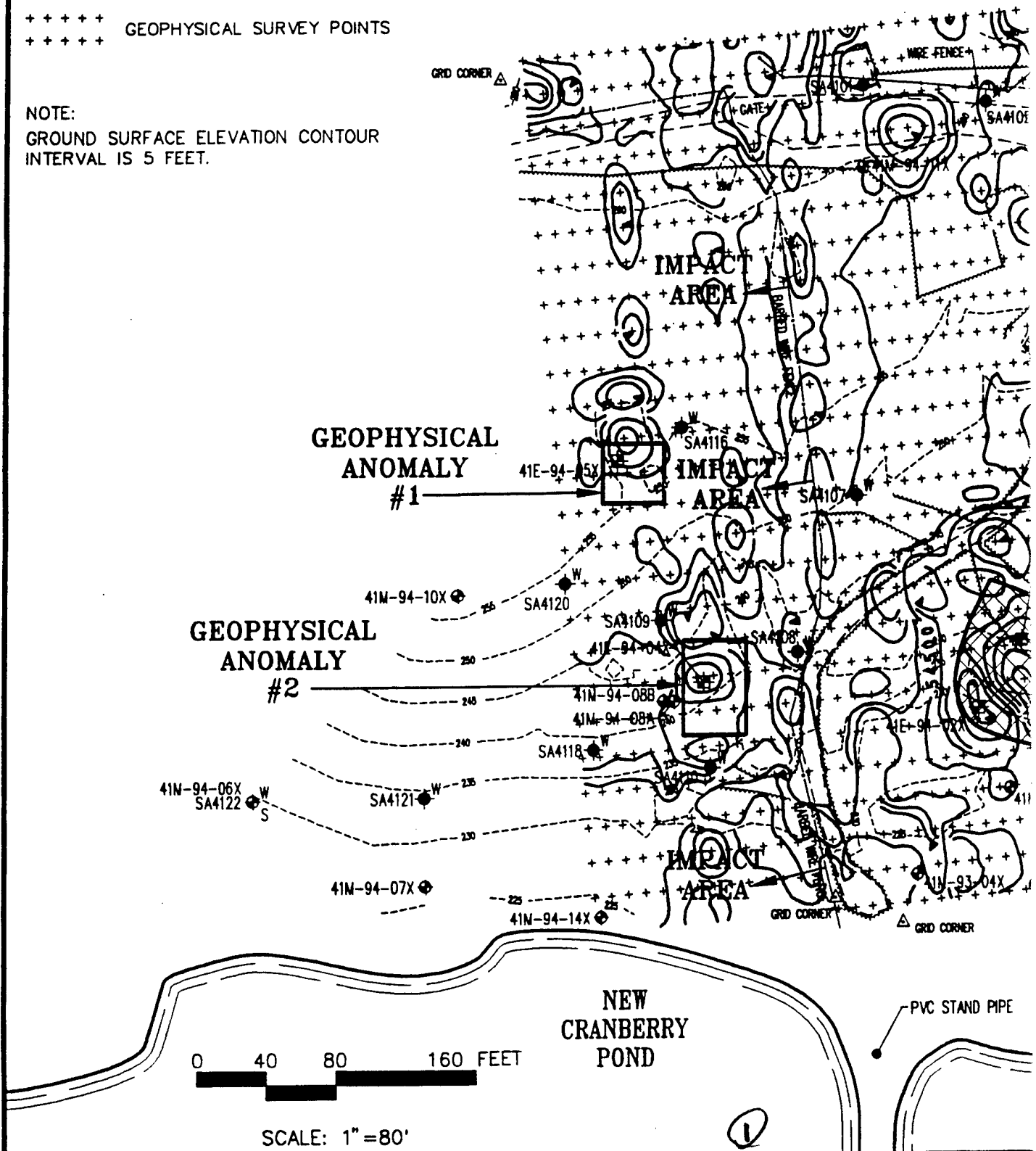


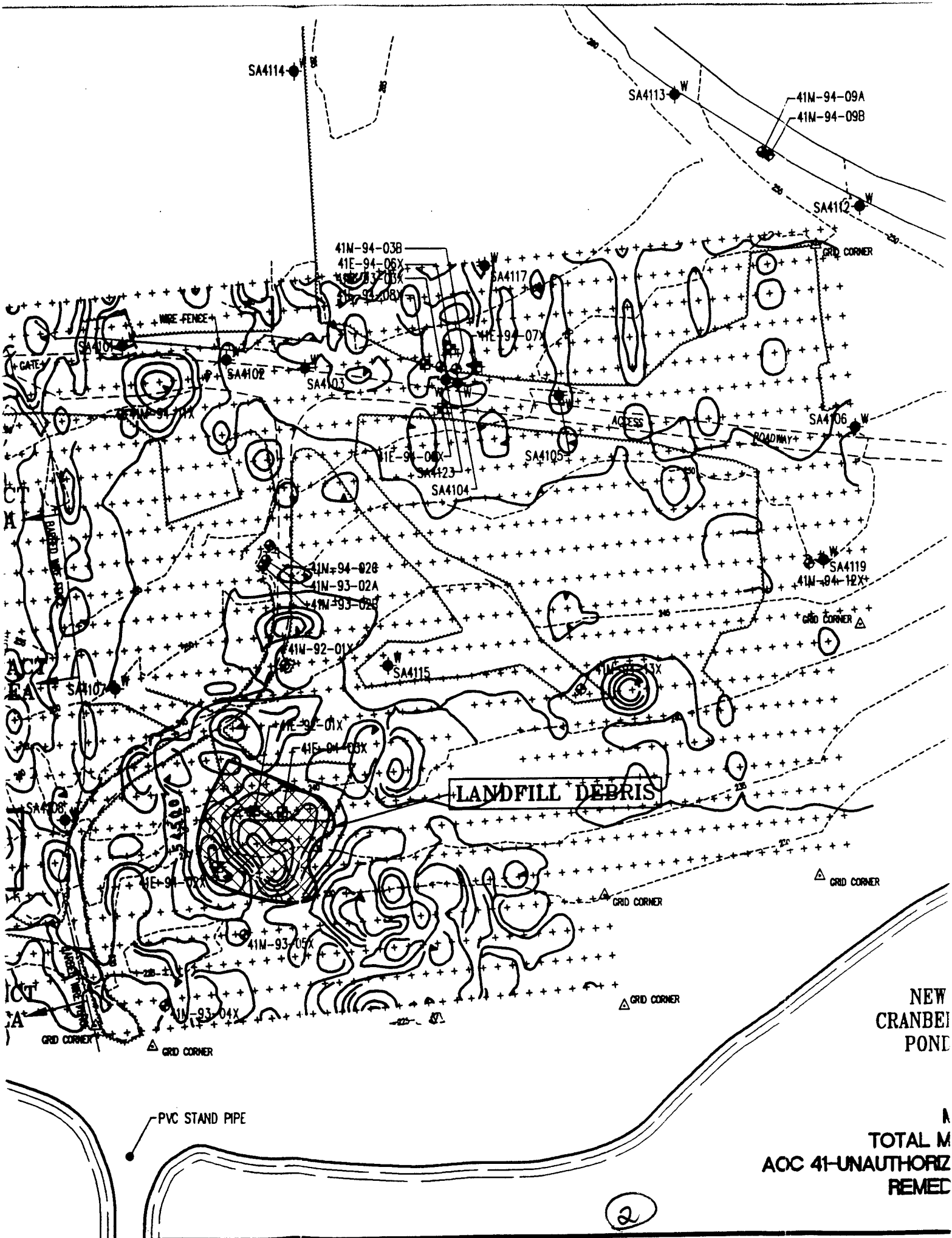
FIGURE 6-6
 INTERPRETIVE THICKNESS OF SILT
 LAYER ELEVATION CONTOURS
 AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
 REMEDIAL INVESTIGATION REPORT
 FORT DEVENS, MA

LEGEND

-  MONITORING WELL
 41M-94-03X
-  SCREENED AUGER BORING
 (WATER ONLY)
 SA4123
-  SCREENED AUGER BORING
 (WATER AND SOIL)
 SA4122
-  TEST PIT
 41E-94-02X
-  TREELINE
- + + + + +
 GEOPHYSICAL SURVEY POINTS

NOTE:
GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.





NEW
CRANBEI
POND

TOTAL M
AOC 41-UNAUTHORIZ
REMED

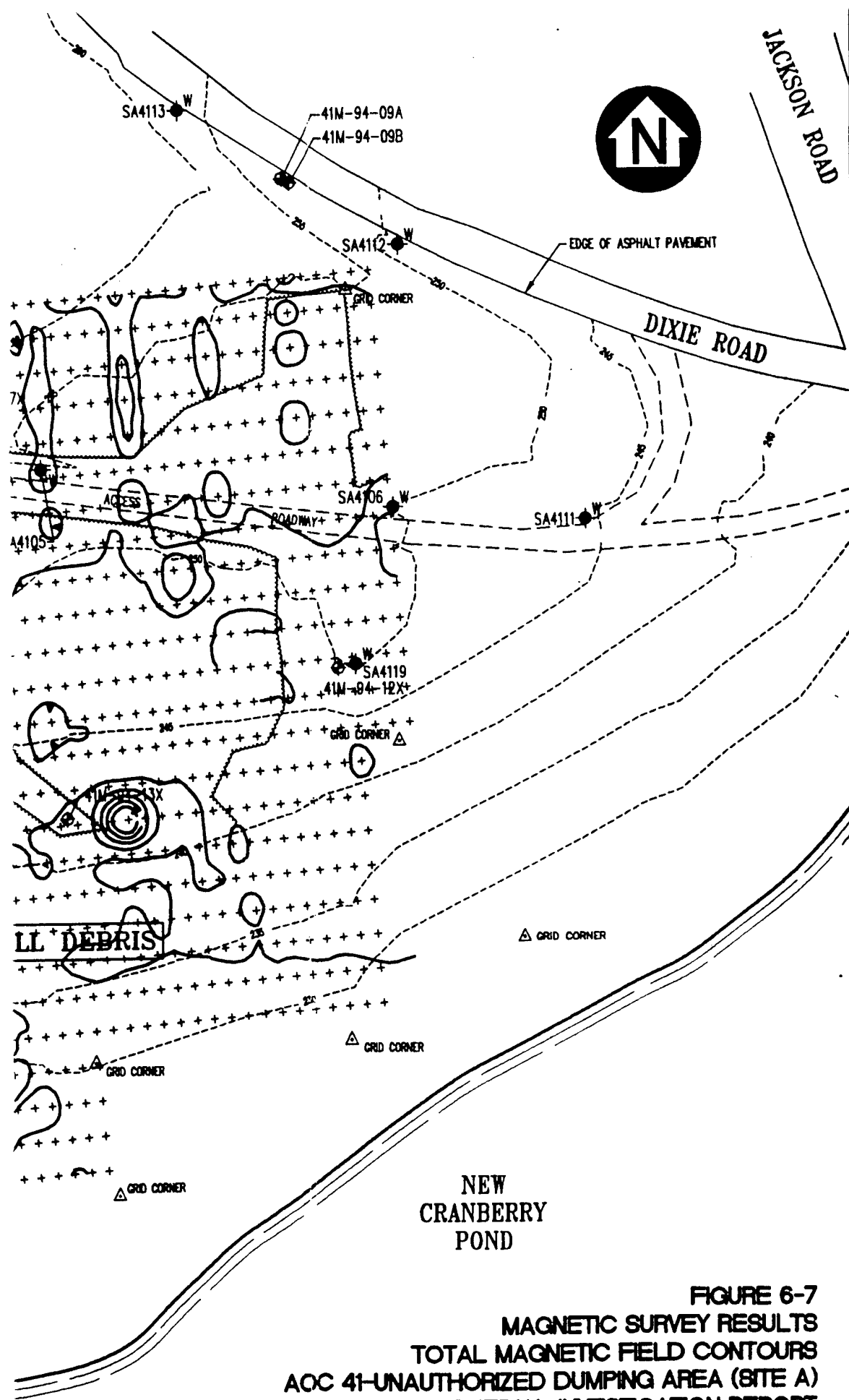






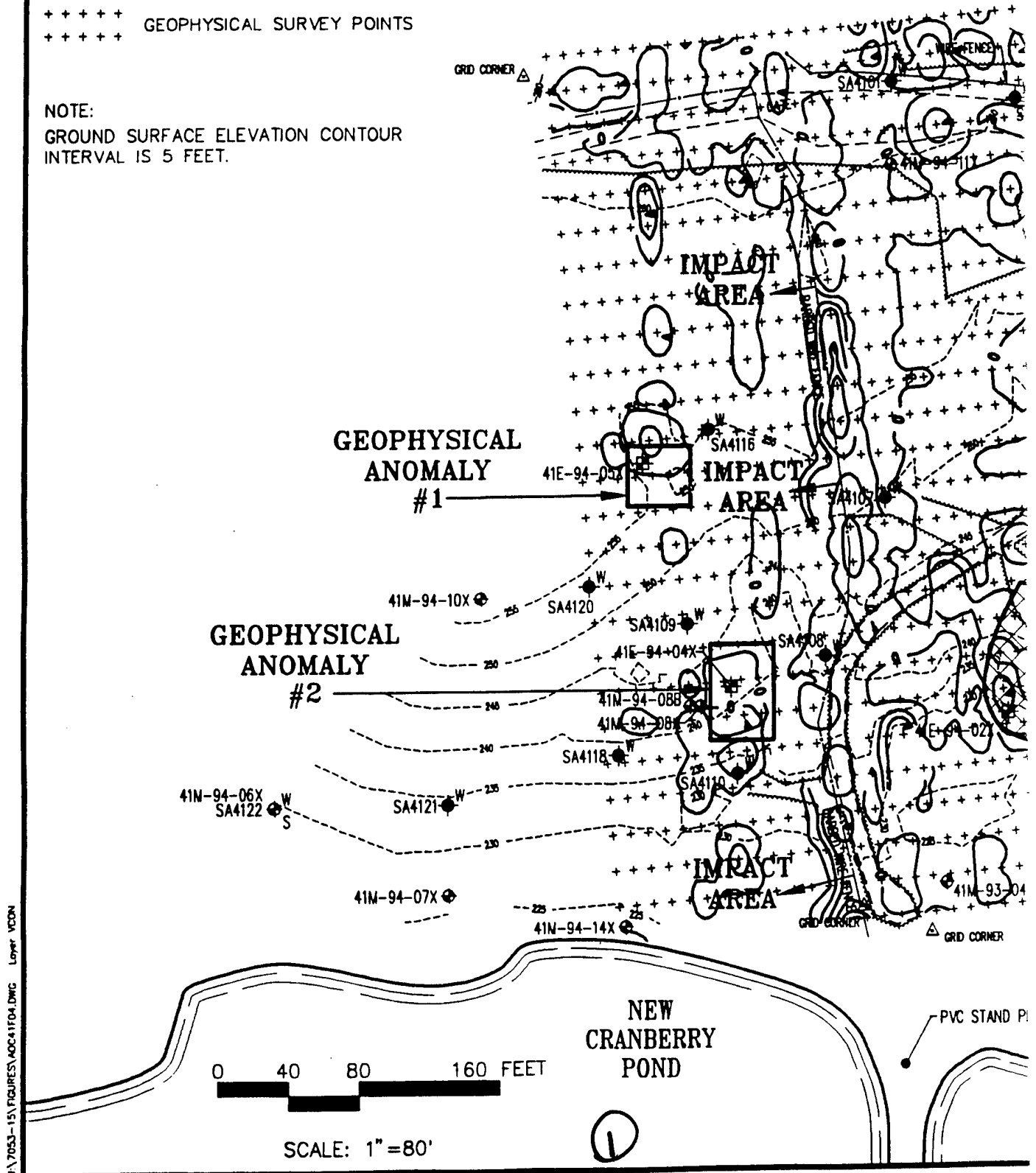


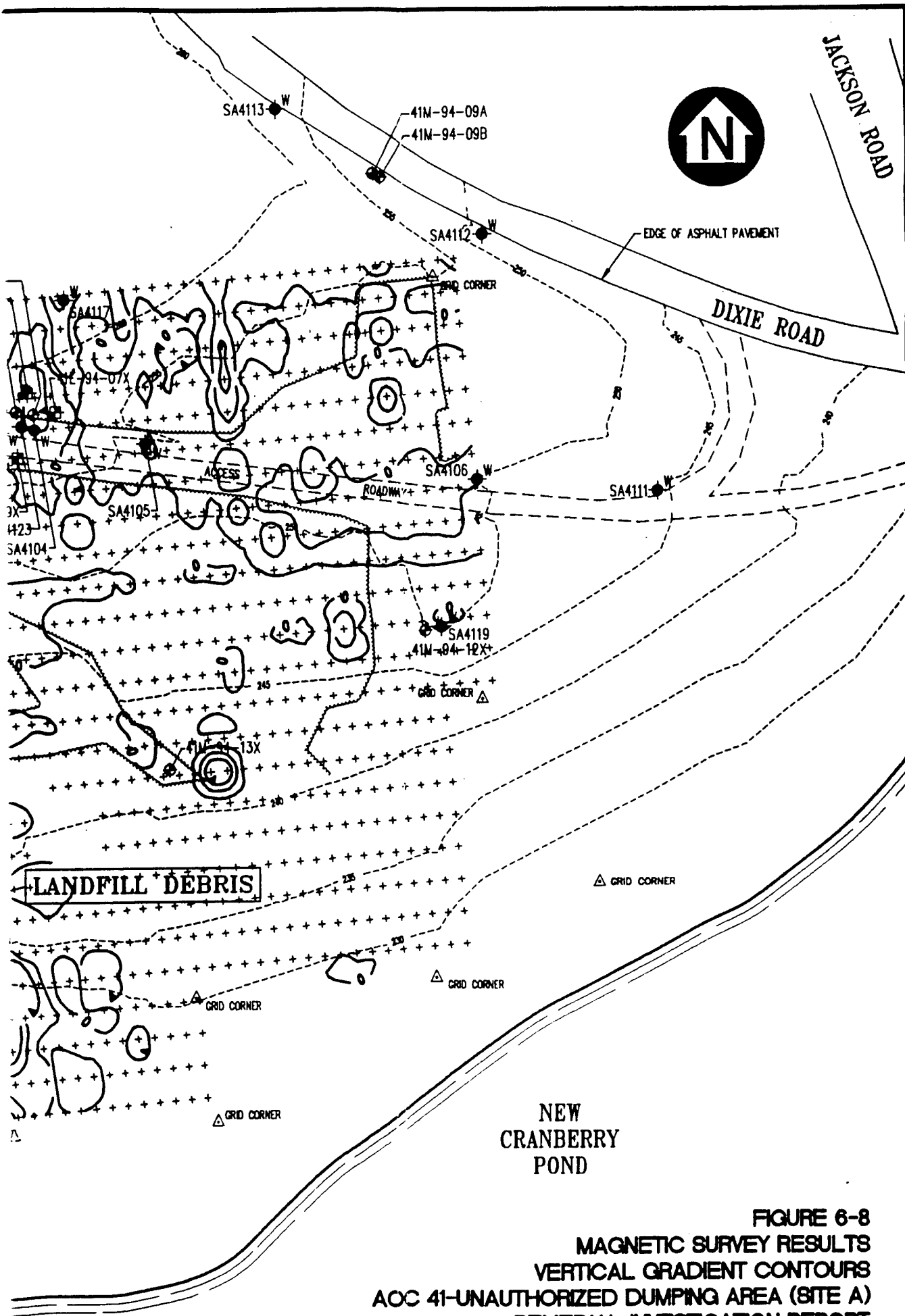
FIGURE 6-7
 MAGNETIC SURVEY RESULTS
 TOTAL MAGNETIC FIELD CONTOURS
 AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
 REMEDIAL INVESTIGATION REPORT
 FORT DEVENS, MA

LEGEND






-  MONITORING WELL
 41M-94-03X
-  SCREENED AUGER BORING
 (WATER ONLY)
 SA4123
-  SCREENED AUGER BORING
 (WATER AND SOIL)
 SA4122
-  TEST PIT
 41E-94-02X
-  TREELINE
-  GEOPHYSICAL SURVEY POINTS

NOTE:
GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.

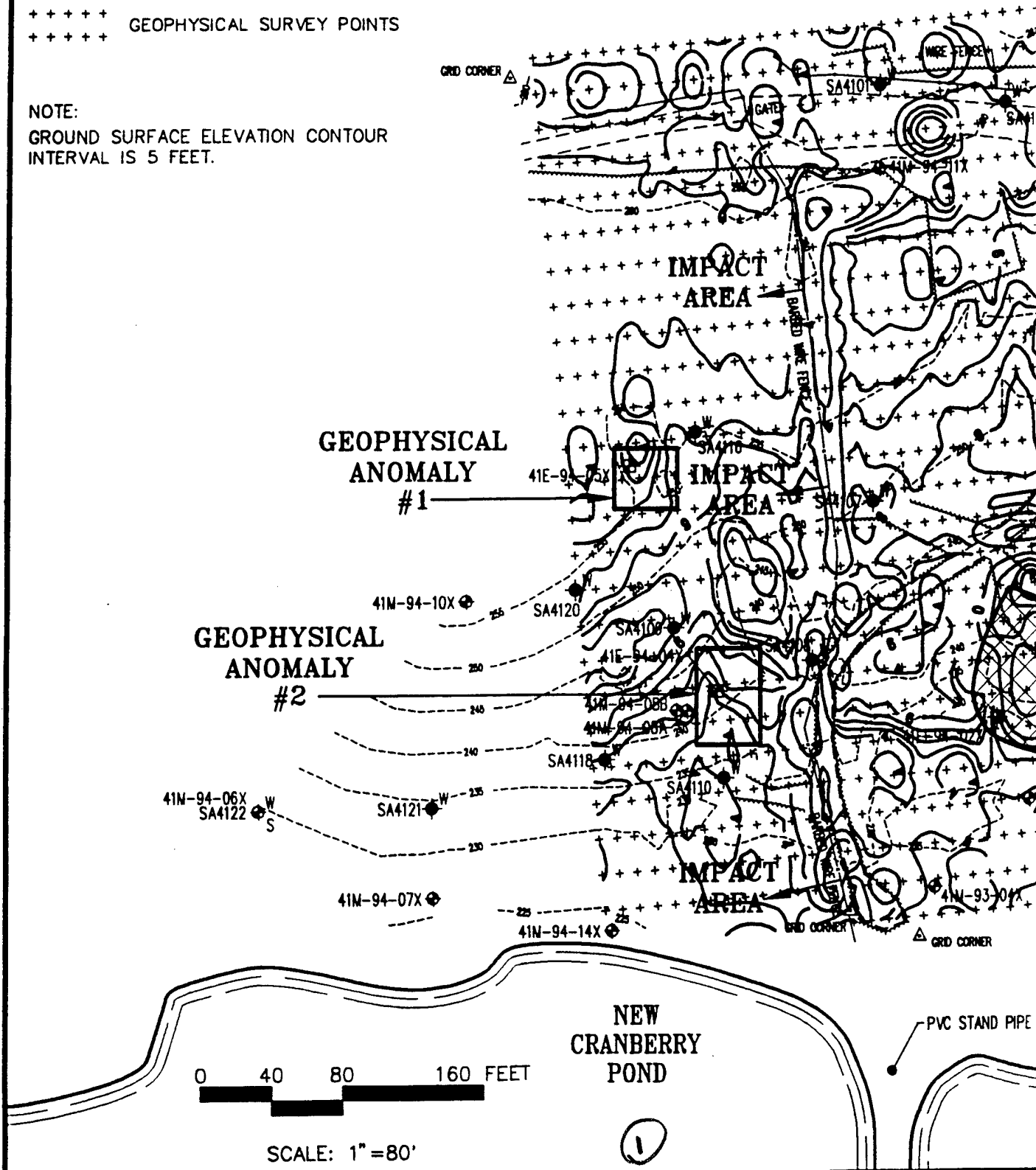


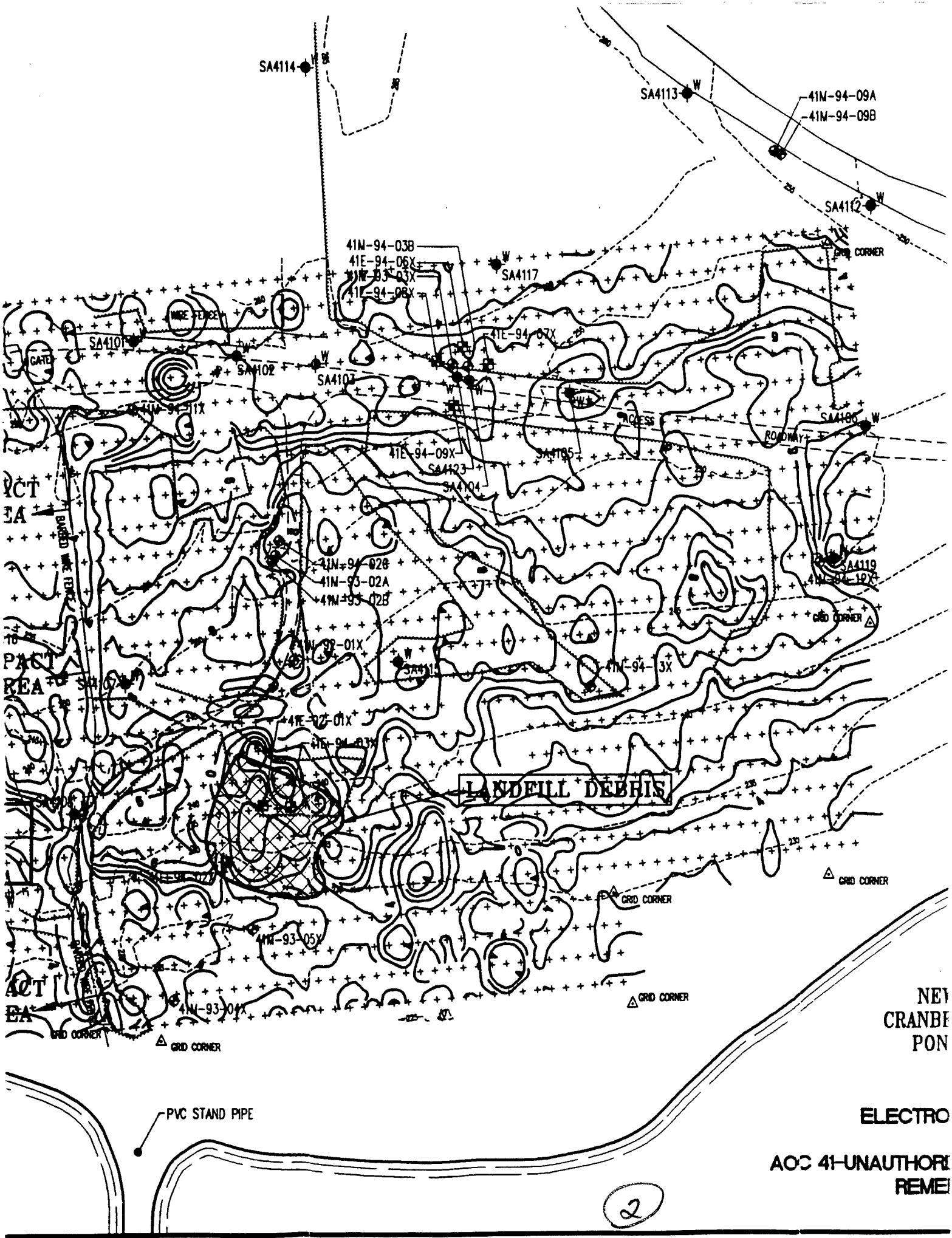


LEGEND

- 
 MONITORING WELL
 41M-94-03X
- 
 SCREENED AUGER BORING
 (WATER ONLY)
 SA4123
- 
 SCREENED AUGER BORING
 (WATER AND SOIL)
 SA4122
- 
 TEST PIT
 41E-94-02X
- 
 TREELINE
- ++++
 GEOPHYSICAL SURVEY POINTS

NOTE:
GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.





SA4114

SA4113 W

41M-94-09A
41M-94-09B

SA4112 W

41M-94-03B
41E-94-05X
41M-93-03X
41E-94-08X

SA4117

SA4101

SA4102

SA4103

41E-94-07X

SA4100 W

41E-94-09X

SA4105

SA4123

SA4104

41M-94-02B

41M-93-02A

41M-93-02B

41M-93-01X

41E-94-01X

41E-94-03X

41M-94-3X

LANDFILL DEBRIS

GRID CORNER

GRID CORNER

GRID CORNER

GRID CORNER

PVC STAND PIPE






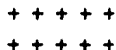
NEV
CRANBE
PON

ELECTRO

AOC 41-UNAUTHORI
REMEI

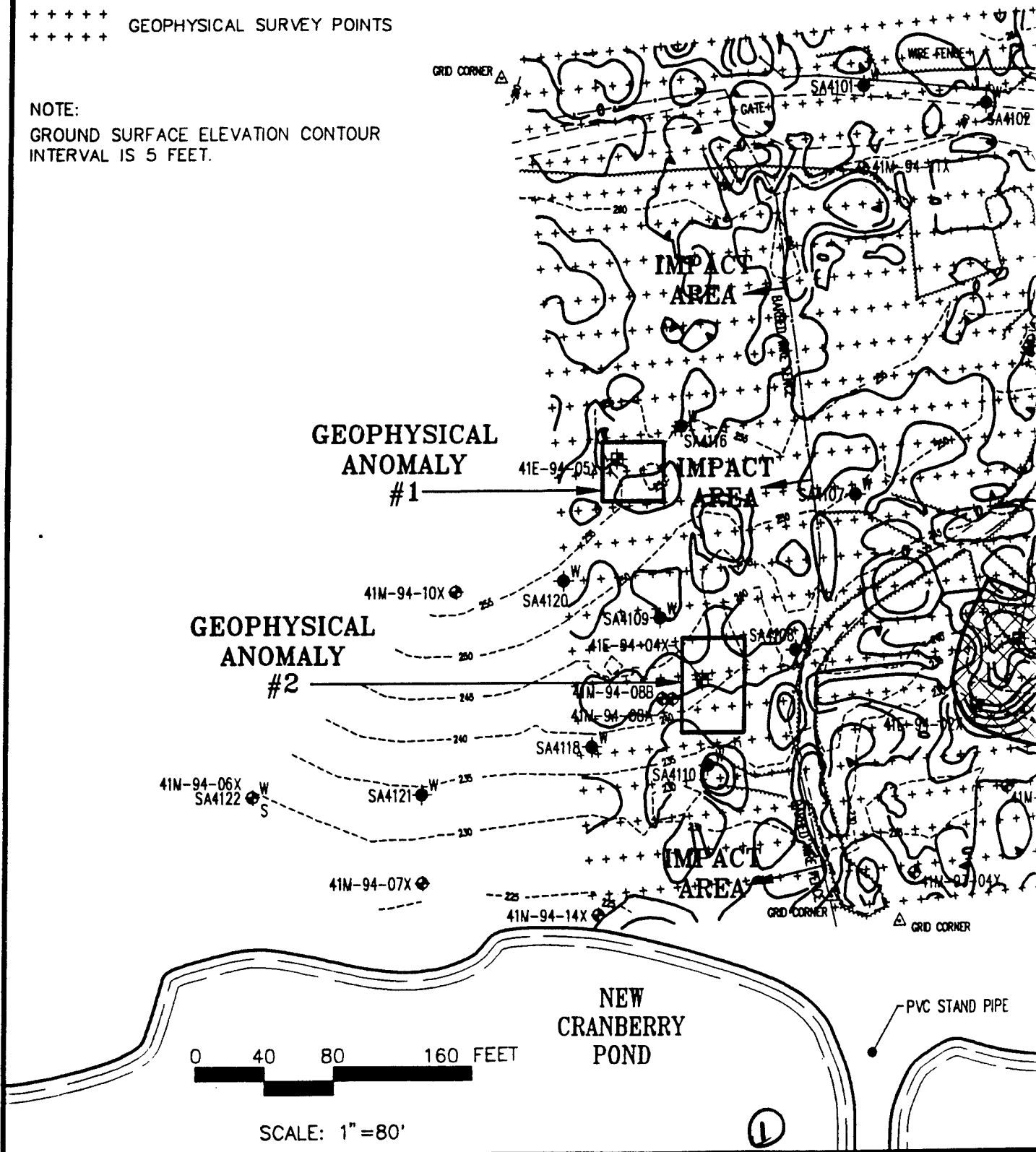
2

LEGEND

-  MONITORING WELL
 41N-94-03X
-  SA4123
 SCREENED AUGER BORING
 (WATER ONLY)
-  SA4122
 SCREENED AUGER BORING
 (WATER AND SOIL)
-  TEST PIT
 41E-94-02X
-  TREELINE
-  GEOPHYSICAL SURVEY POINTS

NOTE:
GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.

SA4



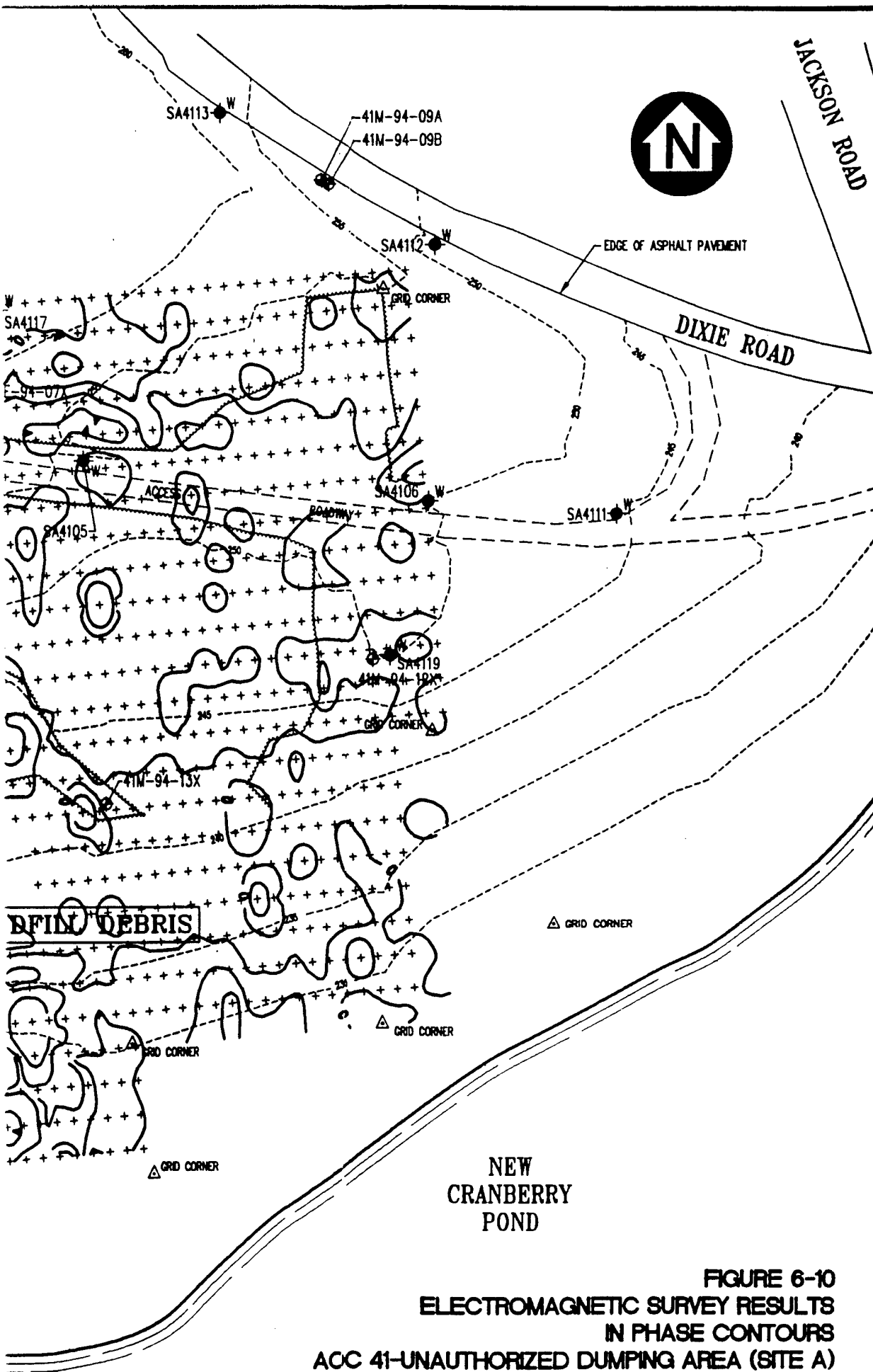






FIGURE 6-10
ELECTROMAGNETIC SURVEY RESULTS
IN PHASE CONTOURS
ACC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

LEGEND

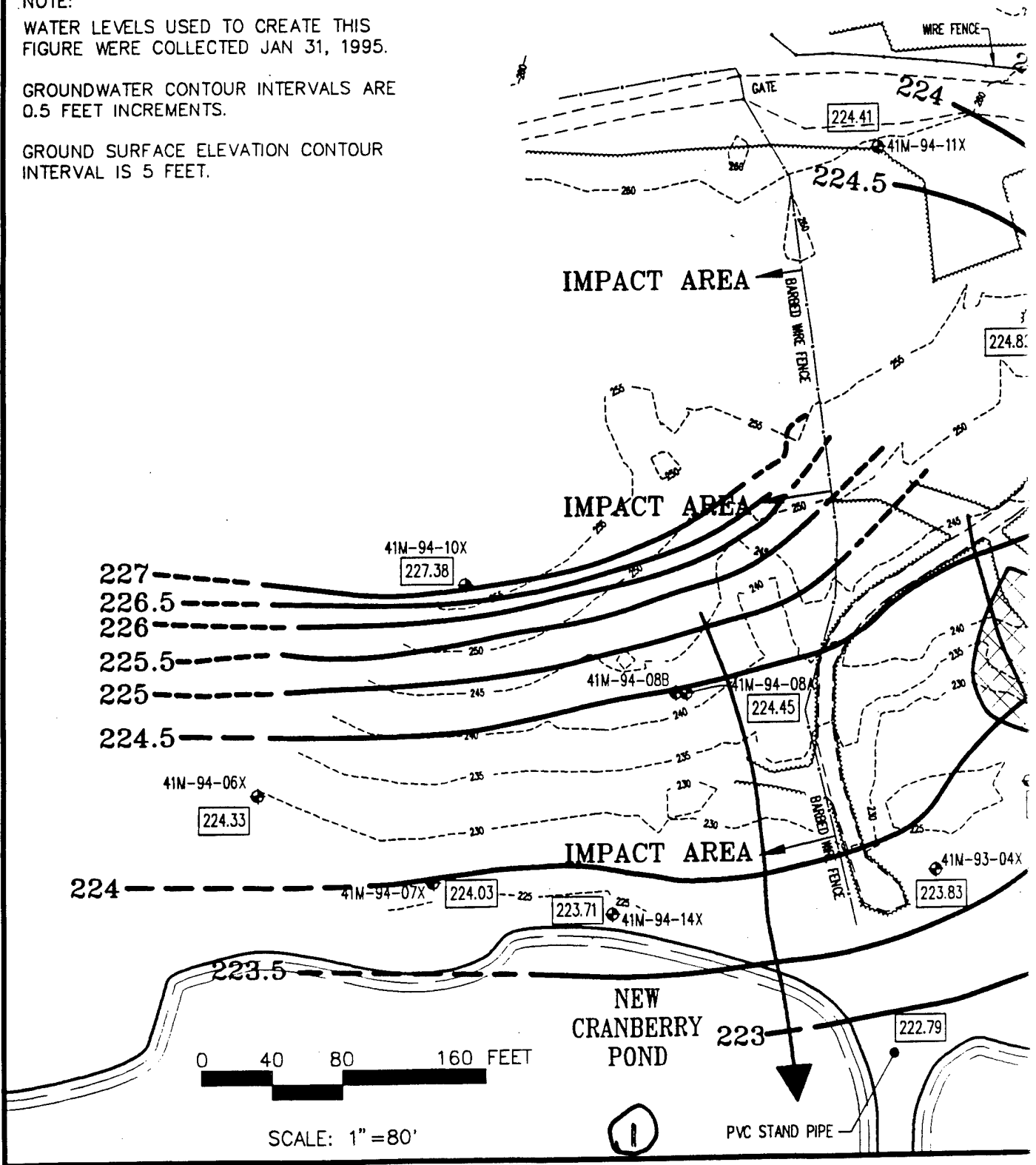
- 
 MONITORING WELL
 41M-93-03X
- 
 TREELINE
- 224 ——— INTERPRETIVE WATER TABLE ELEVATION CONTOUR (FEET, MSL)
- 
 INTERPRETIVE GROUNDWATER FLOW DIRECTION AT THE WATER TABLE
- 
 WATER TABLE ELEVATION AT WELL LOCATION (FEET, MSL)

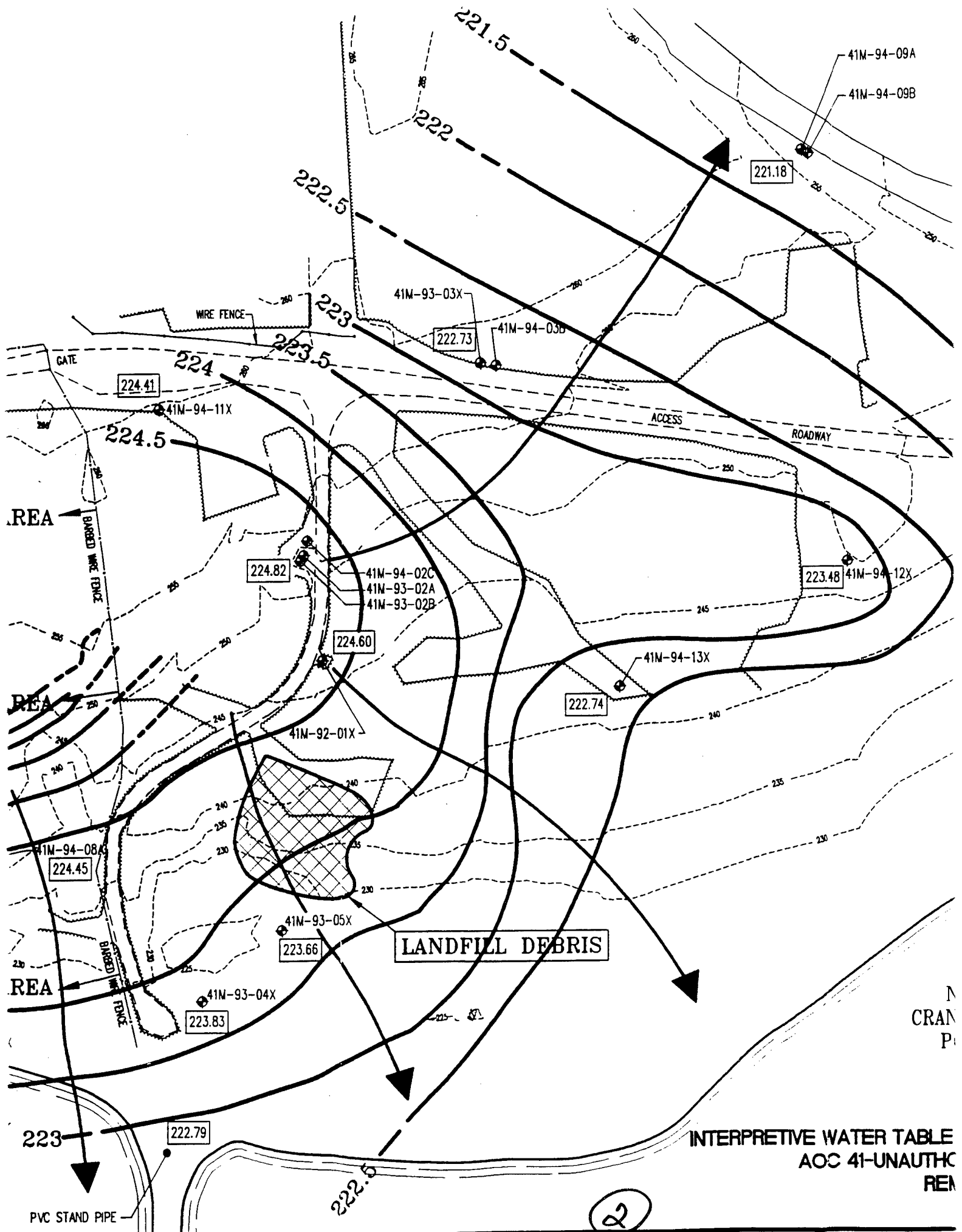
NOTE:

WATER LEVELS USED TO CREATE THIS FIGURE WERE COLLECTED JAN 31, 1995.

GROUNDWATER CONTOUR INTERVALS ARE 0.5 FEET INCREMENTS.

GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.





REA

REA

REA

LANDFILL DEBRIS

INTERPRETIVE WATER TABLE
AOC 41-UNAUTHC
REA

2

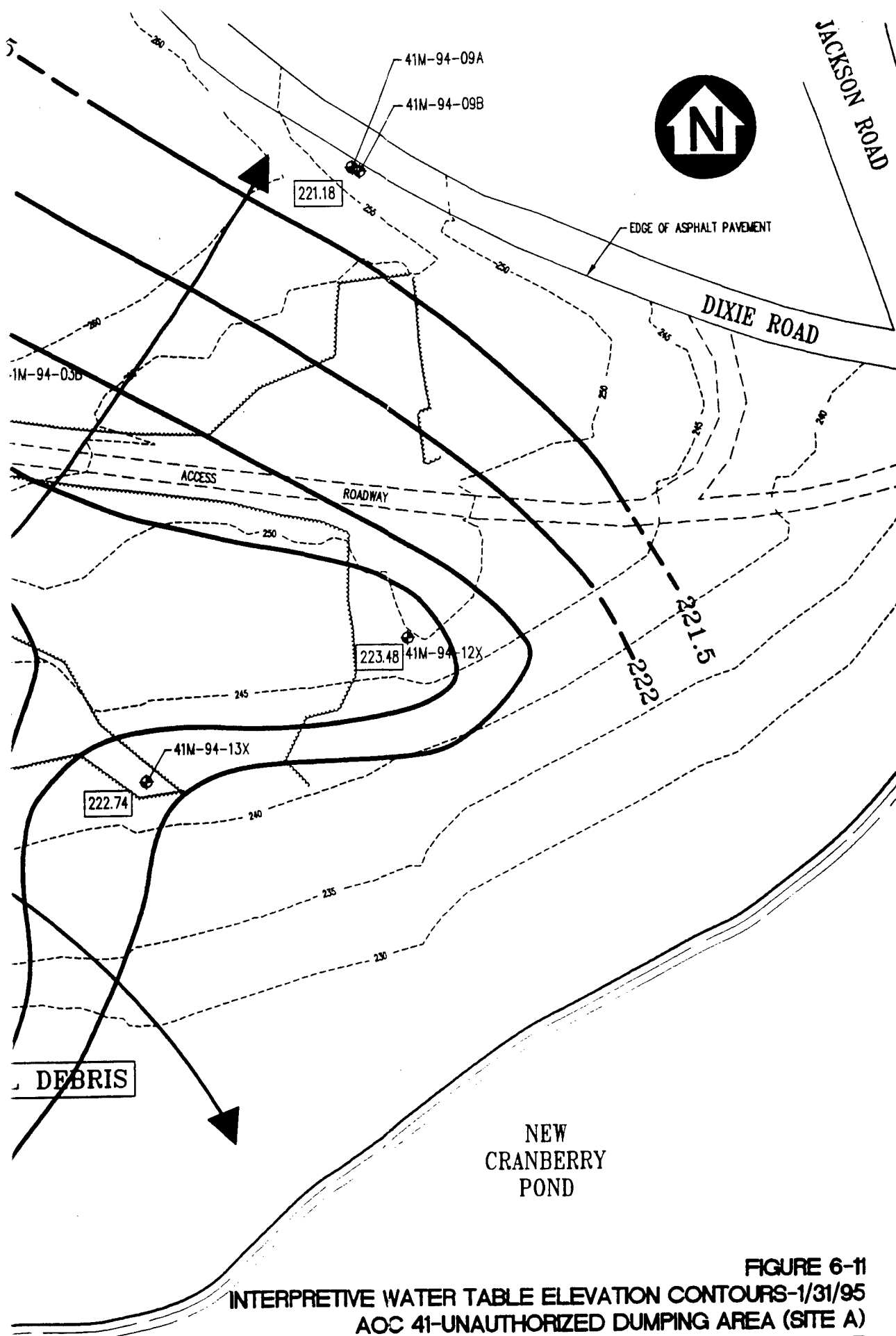





FIGURE 6-11
INTERPRETIVE WATER TABLE ELEVATION CONTOURS-1/31/95
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

LEGEND

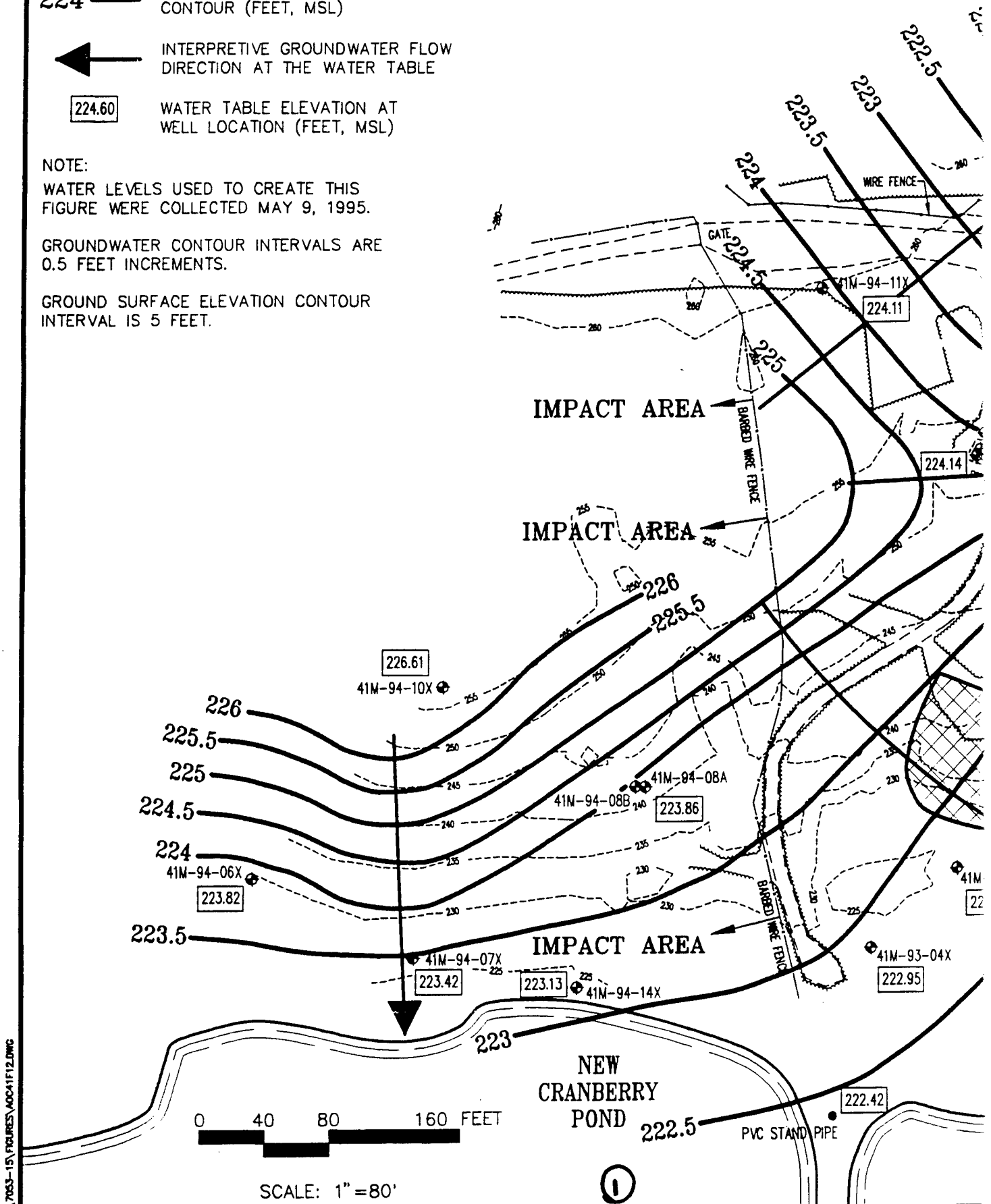
-  MONITORING WELL
-  TREELINE
- 224** — INTERPRETIVE WATER TABLE ELEVATION CONTOUR (FEET, MSL)
-  INTERPRETIVE GROUNDWATER FLOW DIRECTION AT THE WATER TABLE
- 224.60 WATER TABLE ELEVATION AT WELL LOCATION (FEET, MSL)

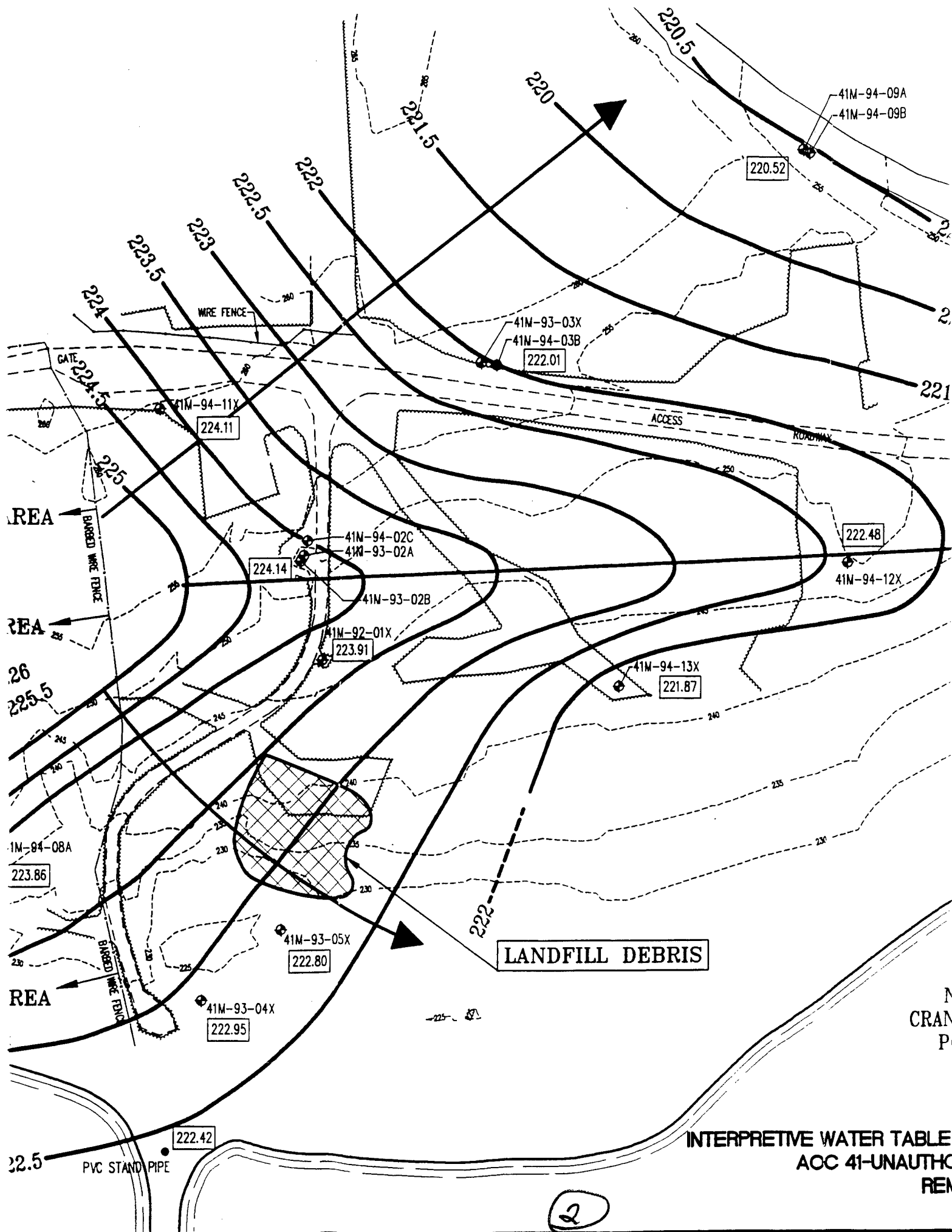
NOTE:

WATER LEVELS USED TO CREATE THIS FIGURE WERE COLLECTED MAY 9, 1995.

GROUNDWATER CONTOUR INTERVALS ARE 0.5 FEET INCREMENTS.

GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.





INTERPRETIVE WATER TABLE
AOC 41-UNAUTHC
REA

N
CRAN
P

2

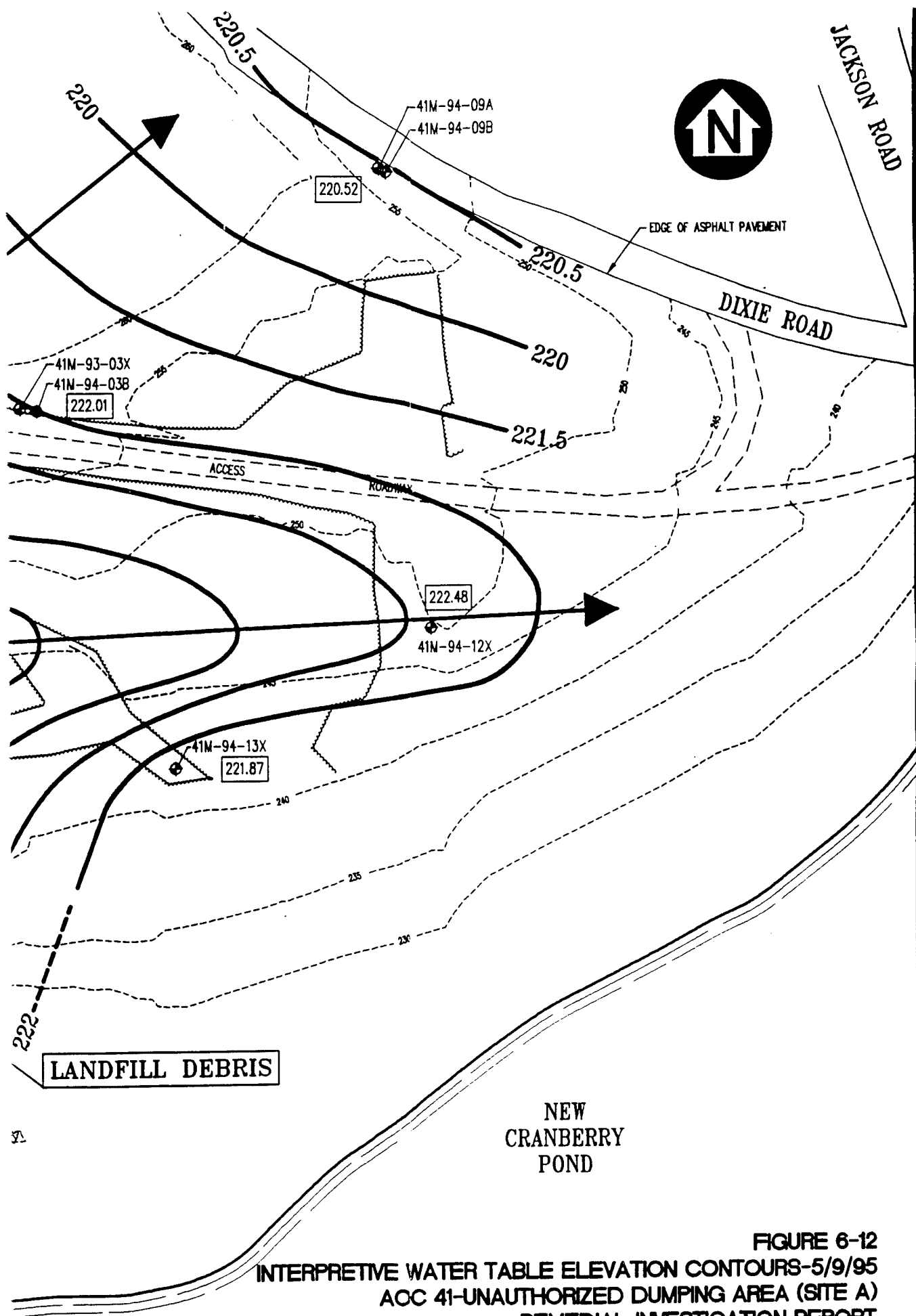





FIGURE 6-12
 INTERPRETIVE WATER TABLE ELEVATION CONTOURS-5/9/95
 ACC 41-UNAUTHORIZED DUMPING AREA (SITE A)
 REMEDIAL INVESTIGATION REPORT
 FORT DEVENS, MA

LEGEND

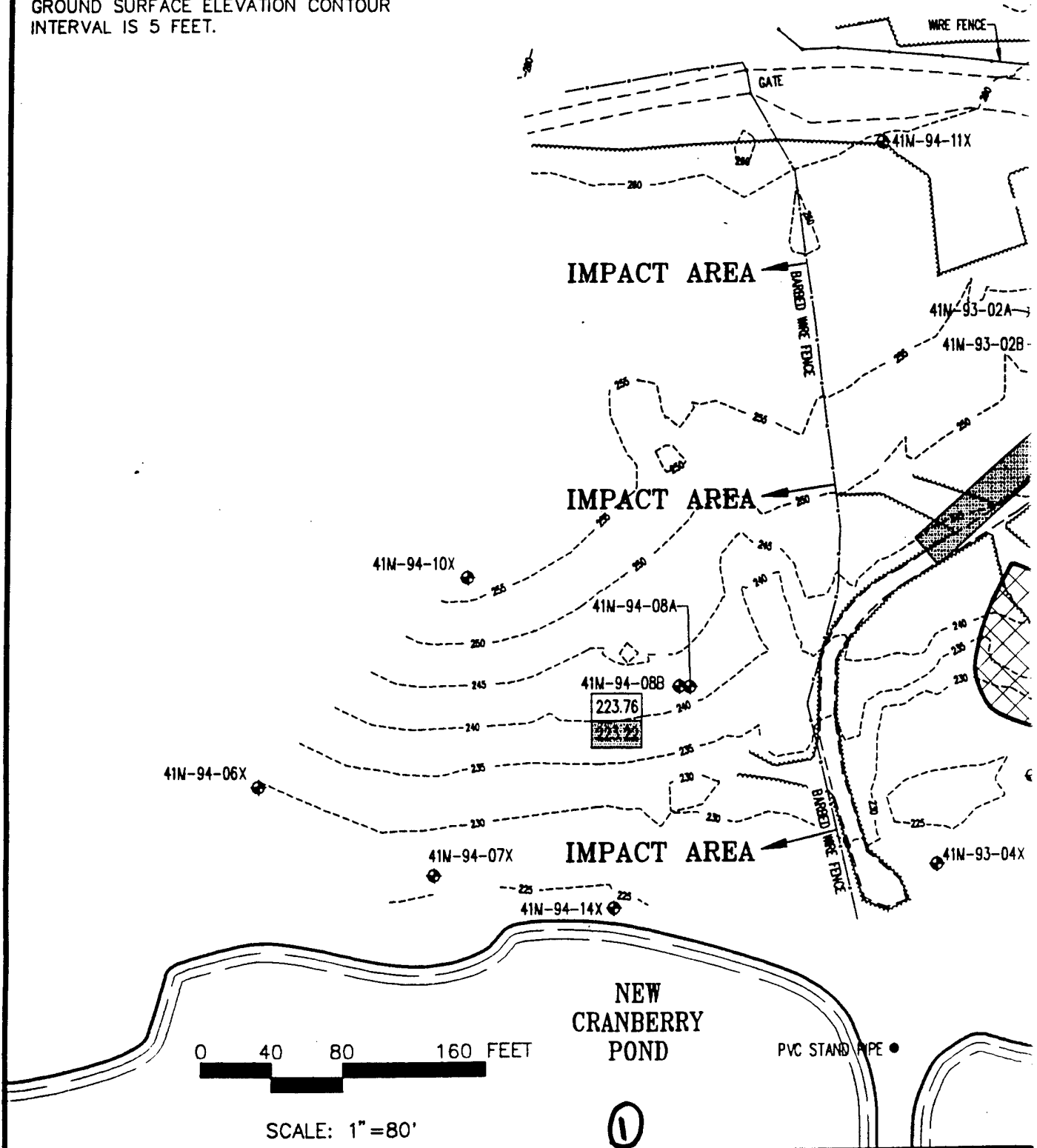
-  MONITORING WELL
 41N-94-03X
-  TREELINE
-  INTERPRETIVE DIRECTION OF DEEP GROUNDWATER FLOW
- 222.13

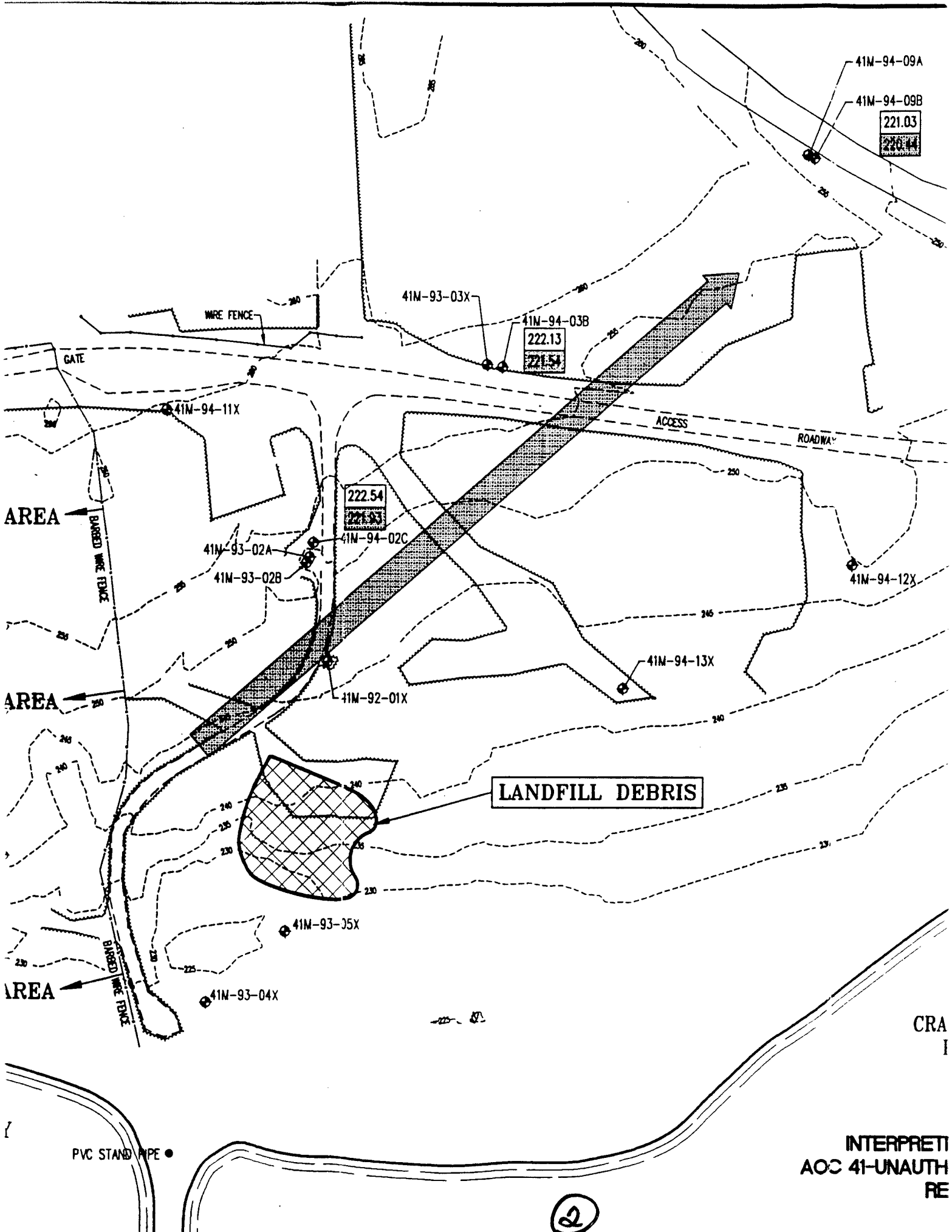
 JAN. 31, 1995 GROUNDWATER ELEVATION

221.54

 MAY 9, 1995 GROUNDWATER ELEVATION

NOTE:
GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.





INTERPRETI
AOC 41-UNAUTH
RE

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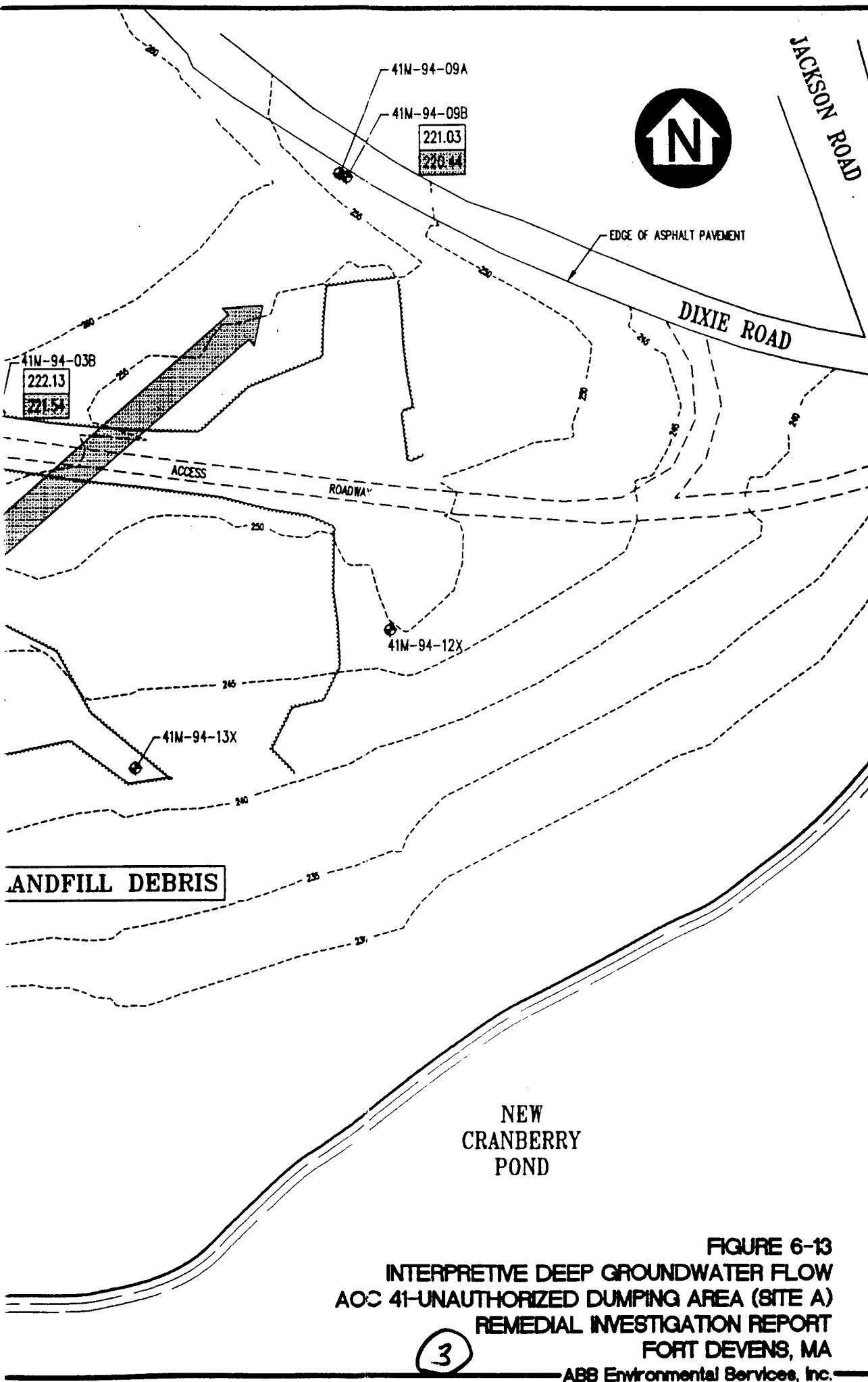
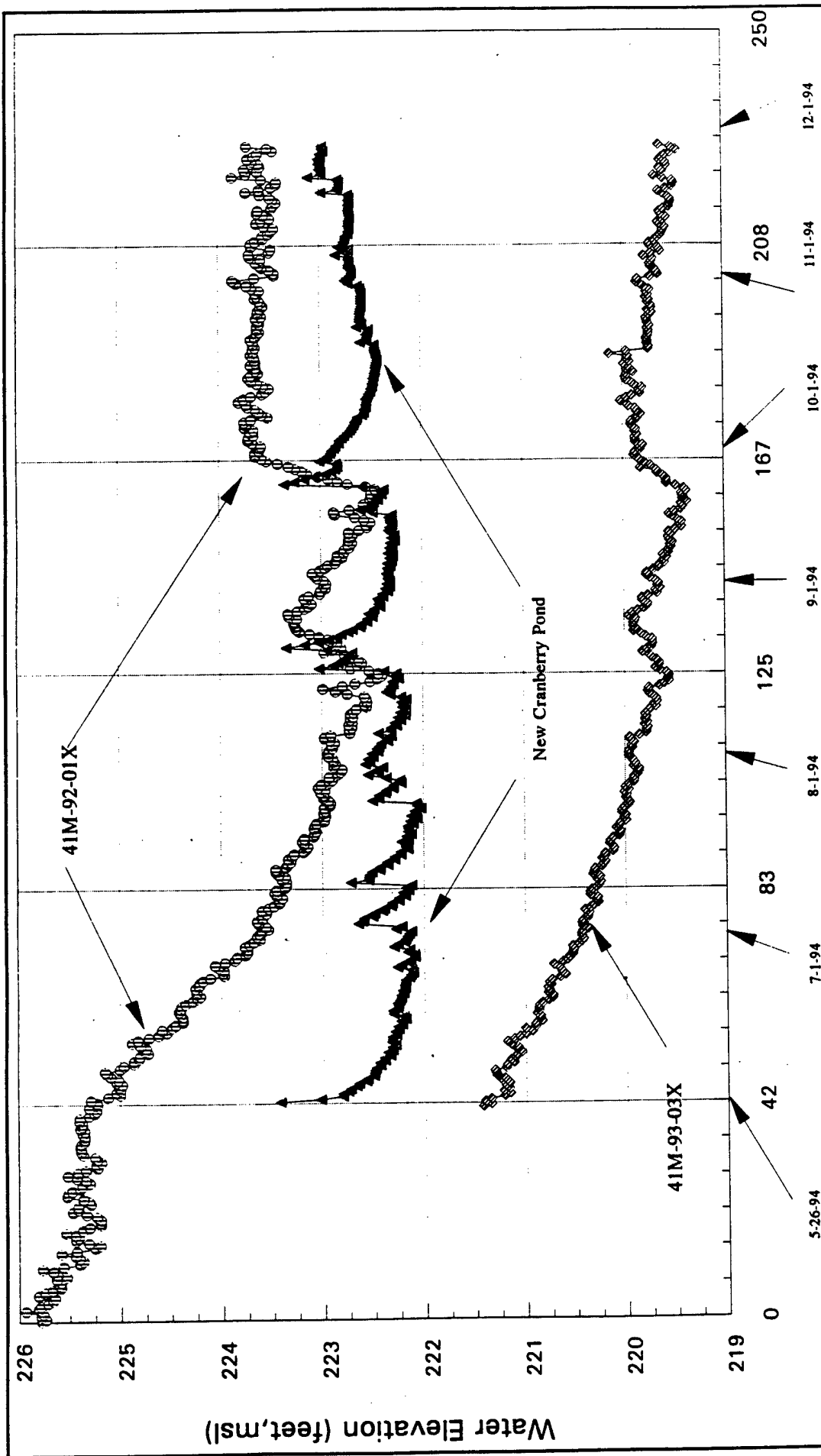


FIGURE 6-13
INTERPRETIVE DEEP GROUNDWATER FLOW
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA



Time in Days Since 1500 hrs on 4-14-94

FIGURE 6-14
LONG-TERM WATER LEVEL MONITORING
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

TABLE 6-1
SUMMARY OF SILT ELEVATION AND THICKNESS DATA
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

EXPLORATION	GROUND ELEVATION (Feet MSL)	DEPTH TO TOP OF SILT (Feet bgs)	TOP OF SILT ELEV. (Feet MSL)	ELEVATION BOTTOM OF EXPLORATION (Feet MSL)	THICKNESS OF SILT (Feet)
41M-92-01X	247.2	5	242.2	211.2	21.5
41M-93-02A	249.6	3.5	246.1	241.6	22.0
41M-93-02B	249.2	3.5	245.7	215.7	22.5
41M-94-02C	250.3	3.5	246.8	200.1	24.0
41M-93-03X	257.5	5.5	252	212.5	18.0
41M-94-03B	257.3	13.5	243.8	192.3	15.0
41M-93-04X	227.8	NE	NA	217.8	NE
41M-93-05X	226.5	NE	NA	216.5	NE
41M-94-06X	229.5	NE	NA	215.5	NE
41M-94-07X	226.5	NE	NA	216.5	NE
41M-94-08A	242.2	7.5	234.7	211.2	15.0
41M-94-08B	242.5	7.5	235.0	198.5	15.0
41M-94-09A	253	18.5	234.5	213.0	7.5
41M-94-09B	252.5	18.5	234.0	197.5	7.3
41M-94-10X	256.8	13.5	243.3	213.8	20.0
41M-94-11X	259.8	14.5	245.3	212.8	18.0
41M-94-12X	249.7	13.5	236.2	209.7	28.5
41M-94-13X	241	3.5	237.5	212.0	24.0
41M-94-14X	224.4	NE	NA	224.4	NE

NOTES:

bgs = below ground surface

NE = Not Encountered

NA = Not Applicable

TABLE 6-2
SUMMARY OF WATER ELEVATION DATA
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVEN, MA

WELL ID	REF. POINT	ELEV. OF REF. PT. (Feet MSL)	OCTOBER 4, 1994		JANUARY 31, 1995		MAY 9, 1995	
			DEPTH TO WATER (Feet)	ELEV. OF WATER (Feet MSL)	DEPTH TO WATER (Feet)	ELEV. OF WATER (Feet MSL)	DEPTH TO WATER (Feet)	ELEV. OF WATER (Feet MSL)
41M-92-01X	PVC	249.50	26.18	223.32	24.9	224.6	25.59	223.91
41M-93-02A	PVC	252.17	6.85	245.32	5.9	246.27	6.44	245.73
41M-93-02B	PVC	252.32	28.65	223.67	27.5	224.82	28.18	224.14
41M-94-02C	PVC	252.94	Not Installed	Not Installed	30.4	222.54	31.01	221.93
41M-93-03X	PVC	259.63	37.69	221.94	36.9	222.73	37.62	222.01
41M-94-03B	PVC	260.13	Not Installed	Not Installed	38	222.13	38.59	221.54
41M-93-04X	PVC	230.63	7.1	223.53	6.8	223.83	7.68	222.95
41M-93-05X	PVC	230.06	7.62	222.44	6.4	223.66	7.26	222.8
41M-94-06X	PVC	231.93	Not Installed	Not Installed	7.6	224.33	8.11	223.82
41M-94-07X	PVC	228.93	Not Installed	Not Installed	4.9	224.03	5.51	223.42
41M-94-08A	PVC	244.75	Not Installed	Not Installed	20.3	224.45	20.89	223.86
41M-94-08B	PVC	244.96	Not Installed	Not Installed	21.2	223.76	21.74	223.22
41M-94-09A	PVC	255.48	Not Installed	Not Installed	34.3	221.18	34.96	220.52
41M-94-09B	PVC	255.23	Not Installed	Not Installed	34.2	221.03	34.79	220.44
41M-94-10X	PVC	259.18	Not Installed	Not Installed	31.8	227.38	32.57	226.61
41M-94-11X	PVC	262.36	Not Installed	Not Installed	37.95	224.41	38.25	224.11
41M-94-12X	PVC	252.09	Not Installed	Not Installed	28.61	223.48	29.61	222.48
41M-94-13X	PVC	243.36	Not Installed	Not Installed	20.62	222.74	21.49	221.87
41M-94-14X	PVC	226.91	Not Installed	Not Installed	3.2	223.71	3.78	223.13
PVC Stand Pipe*	PVC	229.39	6.44	222.95	6.6	222.79	6.97	222.42

NOTES:

* - PVC Stand Pipe in New Cranberry Pond

MSL = Mean Sea Level

PVC - Polyvinyl Chloride

TABLE 6--3
GROUNDWATER VERTICAL GRADIENT CALCULATIONS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

WELL	INTERVAL ELEVATIONS (feet bgs)		SCREENED GEOLOGIC UNIT	January 31, 1995		May 9, 1995	
				GROUNDWATER ELEVATION (Feet MSL)	VERTICAL GRADIENT BETWEEN WELLS (Feet/Feet)	GROUNDWATER ELEVATION (Feet MSL)	VERTICAL GRADIENT BETWEEN WELLS (Feet/Feet)
41M-93-02B	227.2	217.2	CLAYEY SILT/SANDY SILT	224.82	-0.135	224.14	-0.131
41M-94-02C	210.3	200.3	LOWER SAND	222.54		221.93	
41M-93-03X	223.5	213.5	SANDY SILT	222.73	-0.029	222.01	-0.023
41M-94-03B	203.1	193.1	LOWER SAND	222.13		221.54	
41M-94-08A	225.7	215.7	CLAYEY SILT/SANDY SILT	224.45	-0.040	223.86	-0.037
41M-94-08B	208.5	198.5	SANDY SILT	223.76		223.22	
41M-94-09A	224.0	214.0	SANDY SILT/LOWER SAND	221.18	-0.009	220.52	-0.005
41M-94-09B	207.5	197.5	LOWER SAND	221.03		220.44	

NOTES:

Vertical gradients between intervals are calculated using the midpoint of each screened interval to determine distance between screened intervals.

TABLE 6-4
SUMMARY OF IN-SITU HYDRAULIC CONDUCTIVITY TEST RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

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WELL	SCREENED GEOLOGIC UNIT	TYPE OF TEST/ TEST NUMBER	HYDRAULIC CONDUCTIVITY	
			HVORSLEV (cm/sec)	BOUWER AND RICE (cm/sec)
SITE INVESTIGATION				
41M-92-01X	SANDY SILT	RISING HEAD #1 RISING HEAD #2		
SUPPLEMENTAL SITE INVESTIGATION				
41M-93-04X	SAND	RISING HEAD #1 RISING HEAD #2	5.20E-02 2.50E-02	1.20E-02 1.30E-02
41M-93-05X	SAND	RISING HEAD #1 RISING HEAD #2	1.40E-02 1.30E-02	1.20E-02 1.10E-02
REMEDIAL INVESIGATION				
41M-94-02C	LOWER SAND	FALLING HEAD RISING HEAD	1.70E-04 1.00E-04	1.00E-03 6.90E-04
41M-94-03B	LOWER SAND	FALLING HEAD RISING HEAD	1.20E-04 7.40E-05	8.20E-04 6.10E-04
41M-94-06X	SAND	RISING HEAD	1.20E-03	4.00E-03
41M-94-07X	SAND	FALLING HEAD RISING HEAD	9.40E-04 1.20E-03	1.90E-03 3.70E-03
41M-94-08A	CLAYEY/SANDY SILT	RISING HEAD	5.40E-06	1.90E-05
41M-94-08B	SANDY SILT	FALLING HEAD	3.20E-06	2.00E-05
41M-94-09A	SANDY SILT/LOWER SAND	RISING HEAD	2.10E-03	6.60E-03
41M-94-09B	LOWER SAND	FALLING HEAD RISING HEAD	4.40E-04 5.20E-04	2.90E-03 3.50E-03
41M-94-11X	SANDY SILT	FALLING HEAD	1.20E-06	5.10E-06
41M-94-12X	CLAYEY SILT	FALLING HEAD	8.30E-06	3.50E-05
41M-94-13X	CLAYEY SILT	RISING HEAD	8.10E-06	2.90E-05
41M-94-14X	SAND	FALLING HEAD RISING HEAD	2.40E-03 3.1E-03	1.20E-02 1.5E-02

Notes:

cm/sec = centimeters/second

7.0 NATURE AND DISTRIBUTION OF DETECTED SITE CONTAMINANTS

To facilitate the removal and disposal of the waste material located at AOC 41, and to focus in on the media most impacted by past site activities; AOC 41 will be divided into two operable units. The first operable unit will be the waste material and the second will be the groundwater contamination. The waste material in Operable Unit 1 will be handled under the Fort Devens Landfill Consolidation FS which will assess consolidation of waste material from other SAs (SA 6, 12, 13, and AOC 41) or the future South Post Management Plan. Test pit soils result presented in this section were obtained to aid in locating the source of the groundwater contamination. The results for Operable Unit 2 are presented in the following subsections.

The following subsections address the nature and distribution of analytes detected in soil and groundwater collected from AOC 41 during the 1992 SI, the 1993 SSI, and the 1994 RI. Background soil and groundwater data are also presented to aid in the assessment of site-related data. Analytes detected in QC blanks are presented to assess potential contamination of analytical samples introduced during sample preparation and analysis. A complete discussion of the off-site laboratory and field QC programs are presented in Section 3.2 of this report and Appendix H. A complete discussion of the off-site laboratory QC sample results is presented in Appendix H.

In addition to data obtained from off-site analytical laboratory analysis, field analytical data are presented and discussed. During implementation of field programs, field screening results were used to direct placement of soil borings, test pits, and monitoring wells used to define the vertical and/or horizontal distribution of contaminants. Screening results were also used to select off-site laboratory samples. Samples were collected from hot zones to gather information on the nature and concentrations of contaminants, and samples were collected from clean areas for off-site confirmation. Field analytical data are used in the following subsections to complement off-site analytical laboratory data in the assessment of the nature and distribution of detected analytes. A review of field laboratory quality control sample analyses conducted during the 1994 RI program is presented in Appendix H. A discussion of the field laboratory QC sample results is presented in Appendix H.

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This assessment of site-related contaminants relies heavily upon figures and tables to present the field and off-site laboratory analytical data. Hits-only data tables (containing only detected analytes and concentrations for samples within a given media), which were used to create the figures, are presented at the end of this section. The text within the assessment provides detail, interpretation, and analysis that cannot be presented in the figures.

7.1 APPROACH TO CONTAMINATION ASSESSMENT

Off-site laboratory analytical results and field analytical data are the primary data used to assess impacts at the site from suspected past disposal practices. Where applicable, pre-1994 analytical data have been used to assess the site-related contaminants detected at AOC 41. All pre-1994 data were obtained by ABB-ES during the SI and SSI phases of investigation. A summary of pre-1994 and 1994 analyses performed on samples from all media is presented in Table 5-10.

Detected analytes and concentrations in field analytical data have been displayed on figures to aid the reader. Field analytical data shown on the figures, and off-site laboratory hits-only analytical data are also presented in a tabular format at the end of this section. Off-site laboratory analytical results for samples that showed no detection for the entire analytical method (e.g., VOCs) are not listed in the summary tables. A complete list of field and off-site laboratory analytical data is presented in Appendix M and in tables at the end of this section. In addition, tentatively identified compounds (TICs) discussed in Subsection 7.1.1, are presented in Table 7-1. Fort Devens- calculated inorganic background concentrations for analytes detected in soil and groundwater are presented in each off-site laboratory hits-only table. Analytes that exceed background concentrations are highlighted in the tables. A discussion of the Fort Devens background concentrations is presented in Section 4.3 and Appendix L of this report.

A blank contamination evaluation was performed as described in Subsection 7.1.2. This evaluation resulted in the identification of probable laboratory-related contaminants. All data presented in figures and tables are uncorrected for blank contamination, although an "*" has been added to indicate probable blank

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contaminants. Discussions in the contamination assessment evaluate uncertainty regarding potential false positives due to sampling and laboratory contaminants.

7.1.1 Tentatively Identified Compounds/Non-Project Analyte List Compounds

Volatile and/or semivolatile TICs and unknown compounds were detected in several soil samples collected from AOC 41. These compounds are differentiated from target analytes in IRDMIS with an "S" flag in the flagging code field. All TICs associated with AOC 41 are summarized and presented in Table 7-1.

Compounds were tentatively identified by comparing the GC mass spectroscopy (MS) spectra to those contained in the National Bureau of Standards mass spectral library. Once the tentative identification was made based on matching spectra, the appropriate USAEC code name was assigned for that compound. Reported concentrations are considered estimated and are not based on calibration standards. If no compound identification was possible, then the compound became listed as an unknown with an assigned number. The assigned number which accompanies the prefix "UNK" is determined by the relative retention time to the internal standard. For example, if the relative retention time of the compound to 1,4-difluorobenzene is 1.42, the compound would be assigned the number "UNK142" in IRDMIS.

The requirements for making tentative identification of compounds are listed in the POP (ABB-ES, 1993e) as follows:

1. Relative intensities of major ions in the reference spectrum (ions > 10 percent of the most abundant ion) should be present in the sample spectrum.
2. The relative intensities of the major ions must agree within 20 percent.
3. Molecular ions present in reference spectrum should be present in sample spectrum.

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4. Ions present in the sample spectrum, but not in the reference spectrum, should be reviewed for possible background contamination or presence of co-eluting compounds.
5. Ions present in the reference spectrum, but not in the sample spectrum, should be reviewed for possible subtraction from the sample spectrum because of background contamination or co-eluting compounds. Data system library reduction programs can sometimes create these discrepancies.
6. If, in the technical judgement of the mass spectral interpretation specialist, no valid tentative identification can be made, the compound should be reported as unknown.

Several TICs were identified in samples collected from AOC 41 by the contract laboratory (ESE). These include decane, hendecane, nonane, heptane, octane, 2-methylheptane, acetic acid, benzaldehyde, methyl benzoate, and palmitic acid.

Alkanes such as decane, hendecane, heptane, octane, methylheptane, and methylcyclohexane were detected in the sample EX410310. Estimated concentrations of individual compounds ranged from 0.14 to 0.41 $\mu\text{g/g}$. Alkanes are associated with fuel contamination including gasoline and oils (see Table 7-1).

The compounds benzyl acetate, benzaldehyde, methyl benzoate, and palmitic acid were reported as TICs detected in the duplicate sample ED410400. Concentrations of these compounds ranged from 0.4 to 8.1 $\mu\text{g/g}$ (see Table 7-1).

7.1.2 Blank Contaminants

A blank contamination evaluation was performed using rinsate, trip, and laboratory method blank data to determine contaminant contributions originating from non-site-related sources. These potential sources include materials used during borehole advancement and monitoring well installation, field sampling procedures, field equipment decontamination, sample shipment, off-site laboratory storage, and off-site laboratory processing. The majority of off-site analytical data were generated using USAEC-certified analyses. As a result, USEPA data validation procedures related to evaluation of blank contamination and

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establishment of action levels were not applicable to this data. A discussion of contaminants observed in blank from the 1992, 1993, and 1994 field programs is presented in Appendix H. The following approach is taken in the report regarding QC blank contamination:

Organic analytes:

- 1) For non-target VOCs and SVOCs reported as TICs, common organic laboratory contaminants identified by the USEPA (Draft National Functional Guidelines for Organic Data Review, [USEPA, 1991a] and the SOP for CLP Data Validation in the USEPA Region II QA Manual, [USEPA, 1989] with 1992 revisions) are not considered contaminants of concern. The common organic laboratory contaminants identified in this guideline include:
 - Siloxanes, diethyl ether, 1,1,2-trichloro-1,2,2-trifluoroethane, fluorotrichloromethane, and phthalates at levels less than 100 $\mu\text{g/L}$ or 4 $\mu\text{g/g}$ (USEPA, 1991a).
 - Solvent preservatives such as cyclohexane, and related by-products including cyclohexanone, cyclohexenone, cyclohexanol, cyclohexenol, chlorocyclohexene, and chlorohexanol (USEPA, 1991a).
 - Aldol condensation products of acetone including 4-hydroxy-4-methyl-2-pentanone, 4-methyl-2-penten-2-one, and 5,5-dimethyl-2(5H)-furanone (USEPA, 1991a).
 - Additional TICs were detected in blanks. The additional TICs detected in SVOA blanks include 1,2-epoxycyclohexene, mesityl oxide, 2-ethyl-1-hexanol, and hexanedioc acid dioctylester. These compounds have been identified as possible laboratory contaminants in contaminant assessments presented in this document.
- 2) For organic target compounds trends in method and field blanks were evaluated for each sampling program. Tables 7-2 through 7-4

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present a summary of analytes detected in method blanks, rinsate blanks, and trip blanks. A detailed assessment of blank contamination is presented in Appendix H. Several target compounds have been identified by USEPA as common laboratory contaminants including:

- phthalates
- Methylene chloride, acetone, toluene, and 2-butanone (USEPA, 1992a).

Several of these organic analytes were regularly detected in QC blanks. Organic compounds detected in samples at similar concentration ranges as in blanks are identified in the contamination assessment, and results for some compounds are not carried through the risk assessment calculations. In addition, the spatial distribution and relative concentration of common organic laboratory contaminants is evaluated. Discussions related to sampling or laboratory contaminants, and rationale for elimination of data from consideration as site-related contaminants, are presented in the contamination assessment.

- 3) Inorganic Analytes: Several inorganics (metals) were reported in method blanks and rinsate blanks. Sample data as reported in the figures, data tables, and risk assessment tables are uncorrected. The risk assessments carry all uncorrected inorganic data through the calculations. QC blank data is qualitatively evaluated for inorganics exceeding risk thresholds.

During the SSI and RI programs samples were analyzed for a variety of water quality indicators to generate data to support the development of alternatives during the FS process. Low concentrations of method blank contamination was reported for TSS ($\leq 8,000 \mu\text{g/L}$), hardness ($\leq 16,000 \mu\text{g/L}$), and TDS ($\leq 12,000 \mu\text{g/L}$). It is possible that similar concentrations reported in samples may be related to laboratory contamination. Laboratory contamination in these methods at the above concentrations does

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not impact the contamination and risk assessments presented in the document.

7.1.3 Analytical Data Accuracy and Precision

Analytical data accuracy and precision was evaluated using results of matrix spikes (MS) and field duplicate analyses for the majority of off-site analytical methods conducted to support the Devens field programs. Surrogate recoveries were reviewed to evaluate the accuracy of VOA and SVOA measurements. Detailed discussions and presentation of these results are included in Appendix H.

Matrix spike, field duplicate, and surrogate results for the majority of the methods and target analytes evaluated during the SI, SSI, and RI indicate the accuracy and precision of results were within project goal outlined in the Fort Devens POP (ABB-ES, 1992) and USEPA control limits (USEPA, 1988; USEPA, 1989). Trends were reviewed for each set of QC sample data from each field event to determine if qualification of the accuracy of results was needed. Some analytes in groundwater and soil analyses have been identified as estimated with potential biases included. The following items summarize the qualification of results:

1. Based on MS recoveries from the SI and RI analyses, concentrations of antimony and selenium in groundwater are potentially biased low. Selenium was not detected in any groundwater samples collected during the SI, SSI, or RI, and selenium is not interpreted to be important at any of the study areas.
2. Based on MS recoveries for unfiltered groundwater samples during the SI, concentrations reported for arsenic, chromium, copper, lead, nickel, thallium, and zinc are potentially biased low. Similar trends were not observed for the filtered sample analyses associated with the SI field program. These sample locations were recollected during subsequent field programs and similar matrix effects trends were not apparent.
3. Based on MS recoveries for soils from the SI analyses, magnesium and selenium results are potentially biased low. Selenium low recoveries were also reported in the RI MS analyses. No selenium was reported in any soil

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samples and selenium is not interpreted to be important at the Devens sites.

4. Based on MS recoveries for soils from the SSI analyses, arsenic results are potentially biased high. Arsenic concentrations in all samples were below risk levels so the effect of high biased results do not affect risk interpretations.
5. Based on MS recoveries for soils from the RI analyses, results for aluminum, arsenic, iron, magnesium, and manganese are considered estimated values. MS recoveries were reported both above and below project recovery goals and no specific bias is identified.
6. Based on differences observed in field duplicate sample results for target PAHs in sediments and soil samples analyzed during the SSI and RI, PAH in soils and sediments are considered estimated values. This includes pyrene results for sample EX410502, and phenanthrene results sample EX410400.
7. Based on differences observed in field duplicate results for TOC and TPHC in soil and sediments collected during the RI, TOC and TPHC results are considered to be estimated.
8. Based on differences observed in field duplicate soil results for the VOC 1,1,2,2-tetrachloroethane during the RI, results for this compound in soil are considered estimated.
9. Based on differences observed in field duplicate groundwater results for TKN during the RI, TKN results are considered estimated. TKN was collected for use in designing remedial options for groundwater and this parameter is not used in the contamination or risk assessments.
10. Lead results are considered estimated in sample EX410502 based on duplicate sample results.
11. VOA Surrogate Recovery Evaluations:

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- Positive detections of TCE in groundwater sample MX4103X1 and the associated field duplicate collected during the SSI are considered estimated and possibly biased high.
- Positive detections of TCA and PCE in groundwater sample MX4101X1 collected during the SSI are considered estimated.
- Non-detect CRLs and detected target compound concentrations are considered estimated for samples MX4102B1, MX4104X1, and MX4105X1 collected during the SSI.
- Due to high recoveries of surrogate 1,2-dichloroethane-D4 in RI samples MX4103X4, MX4108A3, and MX4108A4, concentrations of target compounds in these samples are considered estimated and possibly biased high.
- Low recoveries of 4-bromofluorobenzene and/or toluene-D8 were reported in samples MX4102A4, MX4113X4, MX4101X5, MX4105X3, MX4102B4, MX4110X4, and MX4112X4. Concentrations reported for detected target compounds and CRLs for non-detected target compounds are considered estimated and possibly biased low. A large bias is not suspected based on acceptable recoveries observed for the other surrogates associated with these analyses.

12. SVOA Surrogate Recovery Evaluation:

- Groundwater sample, MX4102B2, had two low base-neutral surrogate recoveries. No base-neutral target compounds were detected. Base-neutral compound CRLs for this sample are considered estimated and possibly biased low.

7.2 CONTAMINATION ASSESSMENT

The following subsections assess compounds and analytes detected in samples collected from soil gas, soil, and groundwater samples collected during each of the field investigations at AOC 41. Surface soil sample results (other than the test pit

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soil results) will not be discussed in this subsection; rather, they have been summarized in Section 5.0 and will be presented again in the Fort Devens Landfill Consolidation FS or the future South Post land use management plan. Surface water and sediment results will not be discussed in this subsection because previous findings determined that AOC 41 is not impacting the water quality of New Cranberry Pond.

7.2.1 Soil

The following subsections present field and off-site laboratory results for soil and soil gas samples collected from AOC 41. Tables 7-5 through 7-8 present the field analytical data collected during the RI. Off-site laboratory analytical soil data from each phase of investigation are presented in Table 7-9. A complete list of field analytical and off-site laboratory analytical soil data results are presented in Appendix M. A summary of analyses performed on all soil samples is presented in Table 5-2.

7.2.1.1 Field Analytical Soil Results.

TerraProbeSM Soil Gas Results. A soil gas survey was performed in March and April 1995 as part of the RI. The following paragraphs summarize the soil gas survey results. Details of the survey results, including field procedures, are presented as Appendix M.

The soil gas survey at AOC 41 was conducted in the shallow soils around monitoring wells 41M-93-03X and 41M-94-03B in an attempt to find the source area for the solvent contamination detected in the groundwater. This area was chosen because the groundwater results from 41M-93-03X had shown the highest concentrations of site-related contaminants (e.g., TCE).

A total of 22 soil gas samples were collected from 13 locations (TS-01 through TS-13) (see Figure 5-5). A soil gas sample was collected from the 5-foot depth at each location. In addition, five soil gas samples were collected at (7 feet, 9 feet, 11 feet, 13 feet, and 19 feet) at TS-01, and three soil gas samples were collected at (10 feet, 15 feet, and 20 feet) at TS-04. Each of the soil gas samples was analyzed in the field using a portable GC with an electron capture detector. The

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GC was calibrated for TCE, cis-1,2-DCE and trans-1,2-DCE. Table 7-5 presents results of the field soil gas analyses.

Results of the soil gas survey indicate two detectable concentrations of TCE present in the soil vapor around 41M-93-03X and 41M-94-03B at 3.9 parts per billion (ppb) in TS-01 and 3.6 ppb in TS-04 (both samples at 5 feet bgs). These low-level concentrations at only two out of 13 explorations did not indicate a potential source of contamination at this location. Even though the GC detected TCE, and the same groundwater contaminant is present beneath the underlying clayey silt layer at this location, there appears to be no source for groundwater contamination in the shallow soils at this location based upon soil gas results.

TerraProbeSM Sample Results. Soil samples were collected for field analysis from the same 13 TerraProbeSM points used in the soil gas survey completed in March and April 1995 (see Figure 5-5) and were analyzed for TCE, trans-1,2-DCE and cis-1,2-DCE (see Table 7-6). A total of 30 soil samples were collected from 13 locations (TS-01 through TS-07, TS-10 through TS-12, and TS-14 through TS-16) at depths of 30 to 32 feet bgs and 35 to 37 feet bgs. Results of field analysis for TerraProbeSM soil samples indicates TCE is present in soils adjacent to 41M-93-03X and 41M-94-03B at the 30 to 37 foot level. Soil samples were also collected from 18 to 20 feet bgs and 23 to 25 feet bgs at TS-01, and from 18 to 20 feet bgs and 23 to 25 feet bgs at TS-04, to evaluate the distribution of target analytes in the shallower soils. The results of the soil samples collected from 18 to 20 feet and 20 to 27 feet bgs indicated no target compounds were present (see Table 7-6).

TCE and trans- and cis-DCE contamination were detected in soil samples collected between the 30 to 37 foot bgs zone. TCE concentrations ranged from less than the detection limit (1.0 ppb) to 180 ppb in nine out of 14 samples in the 30 to 32 foot sample depth. TCE was detected at levels from less than the detection limit to 77 ppb in seven out of 12 samples at the 35 to 37 foot sample depth. Values for trans-1,2-DCE ranged from less than the detection level to 9.1 ppb in six out of 14 samples in the 30- to 32-foot-deep samples. Values for trans-1,2-DCE ranged from less than the detection level to 4.3 ppb in two out of 12 samples in the 35- to 37-foot-deep samples. The other isomer, cis-1,2-DCE, was not detected in any sample (see Table 7-6).

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The lateral distribution of TCE in soil at this location was similar to the concentration observed in groundwater data collected from screened auger samples collected earlier in the RI (see Subsection 7.2.2). Generally, the concentrations were highest near the 41M-93-03X well cluster and concentrations decreased with distance away from the wells (see Table 7-6).

The vertical distribution of observed TCE contamination coincides with the depth of the water table in this area. Therefore, it appears that the TCE and DCE contamination is due to the sorption of TCE and DCE in groundwater to soil particles at the top of the water table. This area appears to be a secondary source for the solvent contamination in groundwater.

Test Pit Soil Sample Results. Soil samples were collected from five test pits (41E-94-01X through 41E-94-05X) excavated in September 1994 (see Figure 5-3) and were analyzed in the field for BTEX and selected chlorinated solvents (see Table 7-6). These samples were collected to aid in defining potential soil contamination and locate the potential groundwater contaminant source area.

Soil samples were collected from the excavation at a minimum of two separate depths, usually one sample near the ground surface and another near the bottom of the excavation. At two excavations, a third sample was collected from an intermediate depth. Field analytical results for soil samples from each test pit did not indicate the presence of any target analytes (see Table 7-6).

Monitoring Well Boring Results. Soil samples were collected for field analysis from the monitoring well boring 41M-94-03B completed in October 1994 (Figure 7-1). All samples were analyzed for BTEX and selected chlorinated solvents (see Table 7-8). A total of 14 samples were collected at 5-foot intervals from the ground surface to 67 feet bgs. Results of the field analysis indicated that TCE was present in the 30 to 32 foot (4.55 ppb), 35 to 37 foot (5.33 ppb) and 40 to 42 foot (8.58 ppb) samples only (see Table 7-8).

The vertical distribution of observed TCE contamination coincides with the depth of the water table in this boring. Therefore, it appears that this TCE contamination in soil is due to the adsorption of TCE from groundwater to soil particles within the zone of the water table fluctuation. This area around

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41M-93-03X and 41M-93-03B does not appear to be the source of the groundwater contamination.

7.2.1.2 Off-Site Laboratory Analytical Soil Results. Soil samples were collected for off-site laboratory analysis from test pits and monitoring well boring locations completed during each field investigation. Table 5-2 presents the analysis performed on each sample, and Table 7-9 presents the off-site laboratory results of the soil analyses.

Subsurface Soil Samples. Off-site laboratory analytical samples were collected during the advancement of soil borings for monitoring well installation during the SI, SSI, and RI. Table 5-2 summarizes the off-site laboratory analyses completed for each soil sample.

One soil sample was collected from 41M-92-01X during the SI and submitted for TOC analysis only. The results showed a TOC concentration of 199 $\mu\text{g/g}$ (see Table 7-9).

Three analytical soil samples, and one duplicate, were collected from the monitoring well boring for 41M-93-02B, and one analytical soil sample was collected from 41M-93-03X during the SSI and submitted for off-site laboratory analysis (see Table 5-2). Two additional samples were submitted for TOC analysis only, one each from 41M-93-04X and 41M-93-05X. No VOCs, pesticide/PCBs, or explosives were detected in any of the samples. The only SVOC compounds detected were BEHP and di-n-butyl phthalate, which are both common laboratory contaminants. Inorganic analysis results indicated the presence of analytes above the Fort Devens background concentrations in each of the samples. Sodium was detected above the Fort Devens background in each sample and is perhaps indicative of a higher than background site-specific levels of sodium. Sodium was the only exceedance from the 45-foot sample from 41M-93-03X. Other inorganic analytes were detected above the Fort Devens background including calcium, copper and nickel (see Table 7-9).

Test Pit Samples. Freon was detected in all seven soil samples collected from test pits completed below the waste material (41E-94-01X through 41E-94-03X) during the RI (see Table 7-9). Toluene was detected in the duplicate 11-foot soil sample from 41E-94-03X, at concentrations of 0.0012 $\mu\text{g/g}$ (see Table 7-9).

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However, the detection of these compounds appear to be related to laboratory contamination based on the results of the QC program. No SVOCs or TPHC were detected in any of the soil samples collected from these test pits.

Several inorganic analytes were detected above Fort Devens background concentrations. These analytes included cobalt, copper, nickel, and sodium. Soil samples collected from test pits 41E-94-01X through 41E-94-05X were also analyzed for TCLP. Each of the soil samples passed TCLP analysis (see Table 7-9).

VOCs were detected in one of 17 subsurface soil samples, collected from potential groundwater contaminant source area test pits (41E-94-04X through 41E-94-09X). The AOC-related VOCs detected included 1,1,2,2-TCA and toluene. The remaining VOCs were identified as laboratory contaminants based on the results of the QC program (see Table 7-9).

SVOCs were detected in 3 of the 17 soil samples. BEHP, a common laboratory contaminant, was detected in one soil sample collected from 10 feet bgs at 41E-94-07X. Several SVOCs (acenaphthylene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene) were detected at low concentrations (below 1.0 ppb) in the 1-foot soil sample (and the duplicate sample) from 41E-94-04X and the 3-foot soil sample (and the duplicate sample) from 41E-94-05X (see Table 7-9).

TPHC was also detected in the above-mentioned soil sample, as well as the duplicate sample for the 3-foot sample from 41E-94-05X. TPHC concentrations ranged from 47.9 $\mu\text{g/g}$ in the 1-foot sample at 41E-94-04X to 1,450 $\mu\text{g/g}$ in the 3-foot sample at 41E-94-05X. No other SVOCs were detected in the deeper soil samples collected from these test pit locations (see Table 7-9). TOC concentrations are also presented in Table 7-9.

Inorganic analyses of test pit soil samples indicate the presence of several analytes above the Fort Devens background concentrations. Several samples appear to have higher inorganic concentrations, such as 41E-94-01X (9 feet bgs), 41E-94-02X (9 feet bgs) and 41E-94-09X (at 1 foot and also at 10 feet bgs) (see Table 7-9). These samples have concentrations above the Fort Devens background concentrations for several analytes. Analytes that are common to all

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four samples include cobalt, copper, nickel, and sodium. Concentrations of sodium exceed the Fort Devens background concentration in all 12 test pit samples. This observation indicates that the natural occurrence of sodium may be higher at this site than other sites used for the establishment of the Fort Devens background concentration for sodium (see Figure 7-9).

7.2.1.3 Summary of Soil Impacts. Organic concentrations observed in soil, when compared with the organic concentration in groundwater at the same location (e.g., 41M-93-03X well cluster) are considerably lower. This indicates that the contaminants detected in the soil samples collected were not from the source of groundwater contamination, or that the contaminant concentrations at the source area have degraded. The concentration of VOCs, SVOCs, and TPHC detected in the shallow soil sample collected from test pits 41E-94-04X and 41E-94-05X, appear to be related to an underground pipe identified near 41E-94-04X, and burnt waste identified in 41E-94-05X during excavation. The low concentrations of organic soil contaminants detected in the field analysis completed during the RI appear to be consistent with the partitioning of contaminants from groundwater to the clayey silt soils formation found at the water table below AOC 41. These physical properties will be discussed further in Section 8.0, Fate and Transport.

The presence of inorganic contaminants above Fort Devens background concentrations in some test pits and in subsurface soil samples from monitoring well borings appears to indicate that site-specific background concentrations at AOC 41 are consistently higher than the established Fort Devens background concentrations.

7.2.2 Groundwater

The following discussion of groundwater sampling results is divided into two major subsections: 1994 RI field analytical results and off-site laboratory analytical results. The off-site laboratory results include results from six groundwater sampling rounds (Round One through Six). However, the focus will be on the 1994 RI sampling results (Round Five and Six) because these rounds included all new and existing monitoring wells.

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7.2.2.1 Field Analytical Groundwater Results. Groundwater samples were collected for field analysis only during the 1994 RI field program. Field analysis of groundwater samples consisted of collection and analysis of groundwater samples from screened auger borings and all pre-1994 monitoring wells. Each of the groundwater samples was analyzed with a field GC for vinyl chloride; t-1,2-DCE; c-1,2-DCE; benzene; TCE; toluene; TCA; ethylbenzene; m/p xylene; o-xylene; 1,1,2,2-TCA; and 1,2-DCE. A summary of groundwater field analysis samples collected and analyzed is presented in Table 7-10 and shown in Figures 7-1 and 7-2. A discussion of groundwater field analytical results is presented below.

Monitoring Well Samples. Field analytical samples from all of the pre-1994 monitoring wells (41M-92-01X, 41M-93-02A, 41M-93-02B, 41M-93-03X, 41M-93-04X, and 41M-93-05X) were collected and analyzed to assess the current distribution of site-related contaminants in groundwater and to facilitate the placement of screened auger borings (see Figure 7-1). The samples were collected during the screened auger program conducted in September 1994. Monitoring well field analytical data are presented in Table 7-10. Field analytical results from 41M-93-02A are not included in Figure 7-1 or 7-2 due to the location of the well screen being set in the perched water found on top of the clayey silt layer.

TCE and 1,1,2,2-TCA distribution and concentrations in the pre-1994 monitoring wells were in general agreement with pre-1994 analytical data collected from the same wells. TCE and 1,1,2-TCA were detected in 41M-92-01X (16 $\mu\text{g/L}$ and 13 $\mu\text{g/L}$, respectively), 41M-93-02A (28 $\mu\text{g/L}$ and 9.5 $\mu\text{g/L}$, respectively), and 41M-93-02B (23 $\mu\text{g/L}$ and 14 $\mu\text{g/L}$, respectively). Only TCE was detected in 41M-93-03X (450 $\mu\text{g/L}$) (see Table 7-10).

Screened Auger Samples. The objective of the screened auger program was to identify horizontal and vertical distribution of site-related contaminants in groundwater so that optional screened auger and new monitoring well locations could be identified and optimally placed. Screened auger locations and concentration contour maps for TCE and 1,1,2,2-TCA field analytical data are shown on Figures 7-1 and 7-2, respectively.

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The first screened auger boring drilled at AOC 41, SA4104, was drilled to assess the effectiveness of the screened auger technique. SA4104 was drilled adjacent to monitoring well 41M-93-03X. The groundwater samples collected from 41M-93-03X during the SSI indicated that groundwater from this monitoring well had the highest concentrations of site-related contaminants. One sample was collected from the water table at SA4104 corresponding to the screened interval of 41M-93-03X (34 to 44 feet bgs) and one sample was collected from 41M-93-03X. Comparison of the field analytical data from SA4104 and the monitoring well 41M-93-03X is presented on the table below:

SITE ID	DEPTH	VOC CONCENTRATION ($\mu\text{g/L}$)	
		c-1,2-DCE	TCE
41M-93-03X	34-44	ND	450
SA4104	37	ND	496

Comparison of the data indicates the screened auger sample concentrations and monitoring well concentrations of TCE were within the same order of magnitude, and indicated that the screened auger sampling technique would allow for the identification of site-related contaminants in field analytical groundwater samples collected from AOC 41.

Data from screened augers SA4101 through SA4122 were used to determine horizontal boundaries of the zone of impacted groundwater, and the locations of new monitoring wells. A total of six groundwater samples were collected from different depths at screened auger location SA4123. Samples were collected at 5-foot intervals from 50 to 70 feet bgs.

Values for TCE and 1,1,2,2-TCA in all of the field analytical groundwater samples collected from the screened auger borings ranged from less than the detection limit to 496 $\mu\text{g/L}$ and 43 $\mu\text{g/L}$, respectively. Maximum TCE and 1,1,2,2-TCA concentrations were detected in screened augers SA4102 through SA4105, SA4107 through SA4110, and SA4118, with the maximum TCE concentration of 496 $\mu\text{g/L}$ detected in the sample from SA4104 (see Table 7-10 and Figures 7-1 and 7-2). No target VOCs were detected north, east and west of the identified plume. The

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chlorinated solvent cis-1,2-DCE was also detected in SA4108 and SA4118 at 2.5 and 21 $\mu\text{g/L}$, respectively (see Table 7-10).

The majority of screened auger samples were collected from the sandy silt layer located just below the clayey silt layer encountered at the site. A smaller percentage of screened auger samples were collected from the well-graded sand found north of the AOC (referred to as the Upper Sand) and from the sand encountered at the southern limit of the site (see Figure 7-1).

Based on field analytical data, the site-related VOC (TCE, 1,1,2,2-TCA and c-1,2-DCE) plume appears to be vertically confined to the soils at the water table, and centered along a line trending northeast to southwest between 41M-93-03X and New Cranberry Pond (see Figure 7-1 and 7-2).

7.2.2.2 Off-Site Groundwater Laboratory Analytical Sample Results. Two rounds of off-site laboratory analytical samples were collected during each of the field investigations conducted at AOC 41. Table 5-2 presents the samples collected, the field program, and the analyses requested. Table 7-11 presents analytes detected in pre-1994 and 1994 groundwater samples. The following discussion will focus quantitatively on 1994 data, and uses pre-1994 data in a qualitative fashion. Inorganic analyte concentrations will be compared to background concentrations in the following assessment.

Site Investigation Groundwater Results. During the 1992 SI field investigation, ABB-ES installed one groundwater monitoring well (41M-92-01X) in the overburden soils in an apparent upgradient location from the waste material (see Figure 7-1). The well screen for this monitoring well was installed across the water table to monitor for potential floating contaminants.

Two rounds (Round One and Two) of groundwater samples were collected from 41M-92-01X. The Round One sample was collected in September 1992 and Round Two was collected in January 1993. Both samples were submitted for off-site laboratory analysis (see Table 5-2).

The results of the Round One and Two groundwater sampling indicated that several VOCs (TCE, PCE, and 1,1,2,2-TCA) were present in the groundwater at this location. One explosive-related compound (2,4,6-trinitrotoluene) was

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detected in Round One, but not in Round Two. In addition, one pesticide compound (endrin) was detected in the Round Two sample but not in the Round One sample. No other VOCs, SVOCs, pesticides/PCBs, or TPHC were detected in either round (see Table 7-11).

Several inorganic analytes were detected above their Fort Devens background concentration in the Round One and Two unfiltered samples. A filtered groundwater sample was collected during Round Two, and the only analyte detected above background in this sample was potassium (see Table 7-11).

SSI Groundwater Results. During the 1993 SSI field investigation, ABB-ES installed five monitoring wells (41M-93-02A, 41M-93-02B, 41M-93-03X, 41M-93-04X, and 41M-93-05X) upgradient and downgradient of the waste material (see Figure 7-1). The well screens of each of these monitoring wells were installed across the water table to monitor for potential floating contaminants.

Two rounds (Round Three and Four) of groundwater samples were collected from the new and existing monitoring wells. Round Three was collected in October 1993, and Round Four was collected in January 1994. Both rounds of samples were submitted for off-site laboratory analysis (see Table 5-2).

The results of Round Three and Four groundwater sampling showed that the VOCs (TCE, 1,1,2,2-TCA, and 1,2-DCE) detected in the SI samples were still present in the groundwater at the existing monitoring well (41M-92-01X), as well as two of the new SSI wells 41M-93-02B and 41M-93-03X. Concentrations of the detected VOC were generally higher in Round Three than Round Four.

Nitroglycerine was detected in the Round Four groundwater sample collected from 41M-93-03X. Low concentrations of benzene (41M-93-02A) and toluene (41M-93-03X) were also detected during these rounds. SVOCs detected during both rounds were identified as common laboratory contaminants (i.e., BEHP) (see Table 7-11).

Several inorganic analytes were detected above the Fort Devens background concentrations in the unfiltered inorganic samples collected during Rounds Three and Four. The results of the filtered inorganic samples collected during both rounds from all monitoring wells, show that concentrations of antimony, arsenic,

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and manganese were slightly above their Fort Devens background concentration (see Table 7-11).

RI Groundwater Results. Eleven additional monitoring wells were installed as part of the RI field investigation (see Figure 7-1). These wells were installed in upgradient, downgradient, and crossgradient locations. The interpreted groundwater flow direction, used to place these monitoring wells, was based upon the water level data gathered during the SSI. These data indicated that the groundwater flow directions were not south (towards New Cranberry Pond), but rather north-northeast (see Figure 6-10).

Two rounds (Rounds Five and Six) of groundwater samples were collected during the RI field investigation. Round Five was completed in December 1994, and Round Six was completed in March 1995. All groundwater samples were submitted for off-site laboratory analysis (see Table 5-2).

TCE was detected at monitoring wells 41M-92-01X, 41M-95-02B, 41M-94-02C, 41M-93-03X, 41M-93-04X, 41M-94-08A, 41M-94-10X, and 41M-94-14X during Round Five. Concentrations ranged from 1.1 $\mu\text{g/L}$ at 41M-94-14X to 200 $\mu\text{g/L}$ at 41M-93-03X (see Table 7-11). TCE was detected in the same monitoring wells sampled during Round Six, with the exception of 41M-93-04X and the addition of 41M-94-13X. Concentrations of TCE detected during Round Six ranged from 0.9 $\mu\text{g/L}$ (41M-94-13X) to 180 $\mu\text{g/L}$ (41M-93-03X) (see Table 7-11). Monitoring well 41M-94-02C was the only deep groundwater monitoring well to show concentrations of TCE (1.6 $\mu\text{g/L}$ in Round Five and 15 $\mu\text{g/L}$ in Round Six). The groundwater results from other three deep groundwater monitoring wells (41M-94-03B, 41M-94-08B, and 41M-94-09B) indicated that low concentrations (0.51 $\mu\text{g/L}$ in the Round Six sample from 41M-94-03B) or no VOCs were present in either Round Five or Round Six (see Table 7-11).

Additional VOCs (PCE, 1,1,2,2-TCA, cis- and trans-1,2-DCE, toluene, carbon tetrachloride, and carbon disulfide) were detected in groundwater samples collected during Rounds Five and/or Six. PCE was only detected in the Round Five samples collected from 41M-92-01X at a concentration of 2.2 $\mu\text{g/L}$. 1,1,2,2-TCA was detected in four monitoring wells (41M-92-01X, 41M-93-02B, 41M-94-08A, and 41M-94-13X) in Round Five and Six. Concentrations ranged from 0.61 $\mu\text{g/L}$ (41M-94-08A) to 34 $\mu\text{g/L}$ (41M-92-01X) in the Round Five

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samples, and 4 µg/L (41M-93-02B) to 38 µg/L (41M-94-08A) in the Round Six samples. Cis- and trans-1,2-DCE were detected in Round Five groundwater samples collected from two monitoring wells (41M-93-02B and 41M-94-08A). Concentrations were 1.8 µg/L and 1.5 µg/L, respectively. These same compounds were only detected in the sample collected from 41M-93-02B during Round Six. Toluene was detected at low concentrations in Round Five samples only, at 10 different monitoring wells. However, based on the blank data assessment presented in Subsection 7.1.2, it appears that a majority of the toluene concentrations can be attributed to method blank contamination (see Table 7-2). The toluene concentrations detected in the groundwater samples collected from 41M-93-02A (2 µg/L) and 41M-94-02C (2.1 µg/L) do not appear to be a result of the method blank contamination. Carbon tetrachloride was detected in the Round Six groundwater sample only, from 41M-94-08A at a concentration of 3.5 µg/L. This compound was not detected in the Round Five sample. Carbon disulfide was detected only in the Round Five (9.2 µg/L) and Round Six (1.1 µg/L) samples collected from 41M-94-10X. The remaining VOCs (chloroform and methylene chloride) detected in samples from Rounds Five and Six are apparently a result of off-site laboratory contamination (see Table 7-11).

The only SVOC detected in the Rounds Five and Six groundwater samples was BEHP, which appears to be attributable to laboratory contamination based upon the results of the QC program. Each of the PAL inorganic analytes, except for mercury, was detected above its Fort Devens background concentrations in the unfiltered groundwater samples. However, results for filtered inorganic samples indicated that only antimony, arsenic, potassium, copper, manganese, magnesium, sodium, and zinc were detected above the Fort Devens background. The differences between the unfiltered and filtered results and the TSS results, indicated that the inorganic concentrations detected in the unfiltered inorganic samples is a result of suspended solids not AOC-derived contamination.

7.2.2.3 Summary of Groundwater Impacts. The groundwater results of Rounds Five and Six at AOC 41 indicate the presence of several VOCs (TCE; PCE; 1,1,2,2-TCA; cis- and trans-1,2-DCE; toluene; carbon tetrachloride; and carbon disulfide) and several inorganic analytes above their Fort Devens background concentrations in unfiltered samples. The distribution and relative concentration of the VOC contaminants is consistent in both field and off-site laboratory results. This observation is the most significant feature of the contamination assessment at

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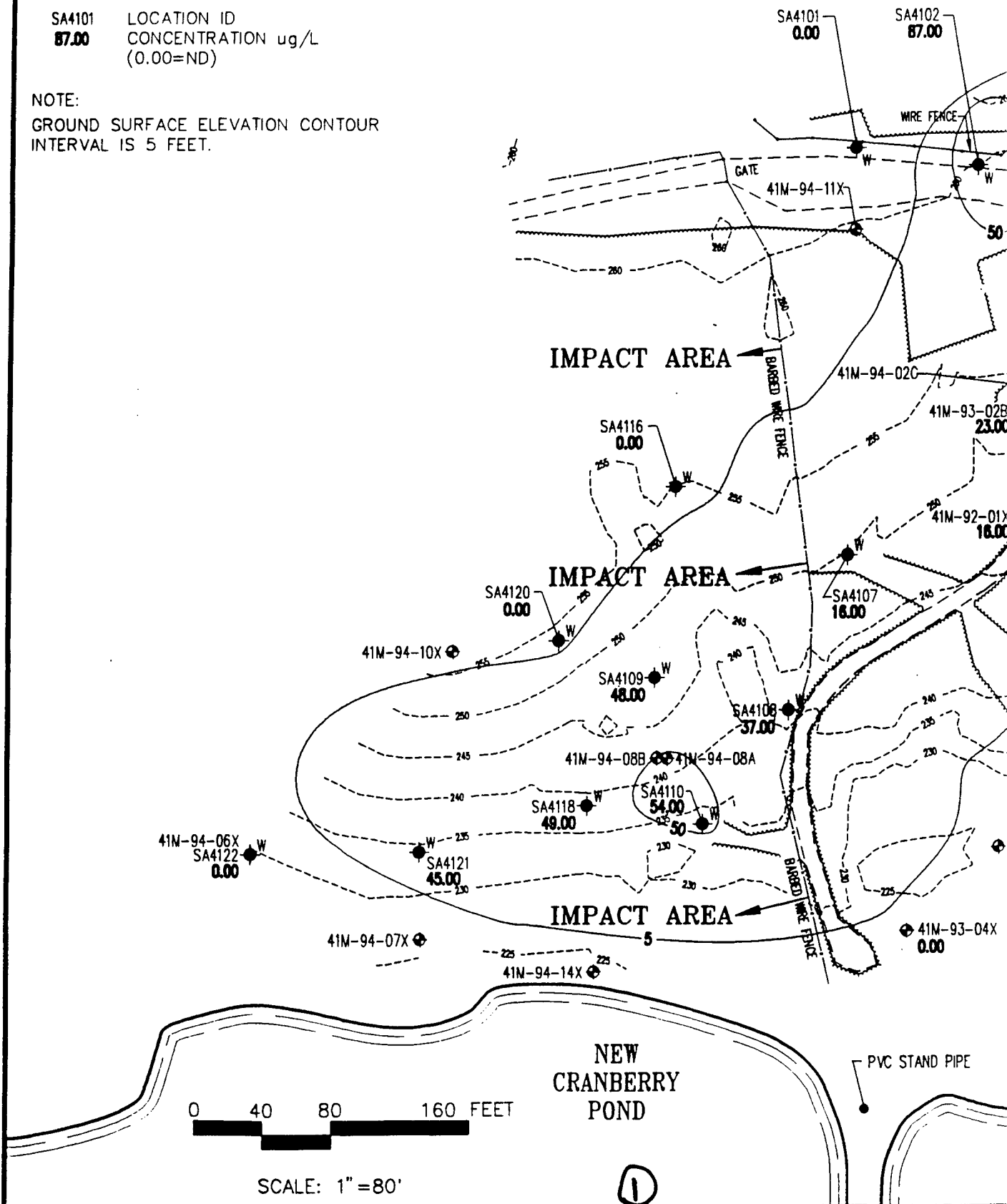
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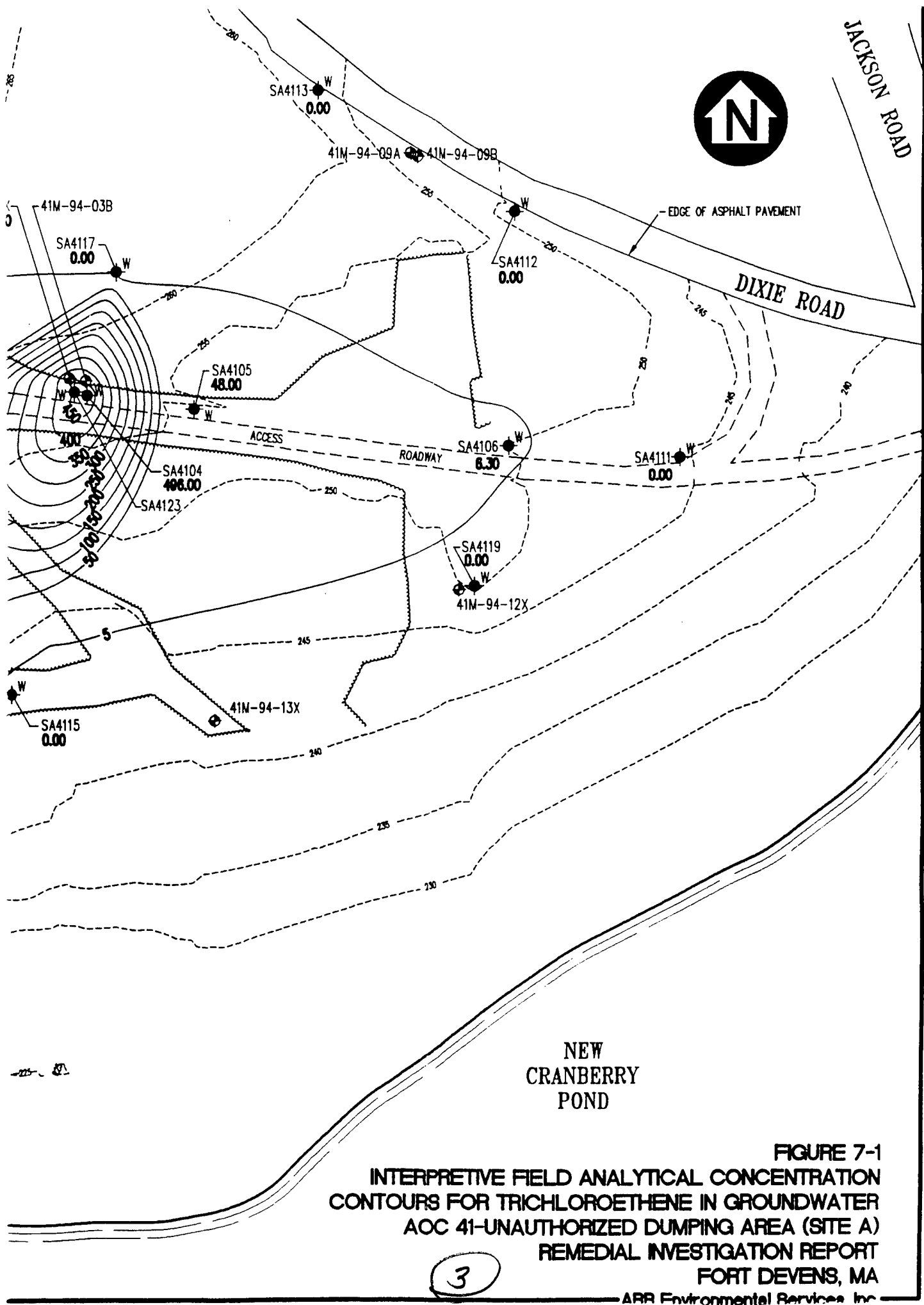
this site. The groundwater is contaminated with VOCs, but the distribution of that contaminant plume appears to be well defined (Figures 7-1 and 7-2). The source of this VOC contamination, particularly the chlorinated solvents, has not been precisely located; however, it does appear to be within the area investigated during the RI. It is important to note that the VOC contamination appears to have almost no movement based upon the consistent contaminant values and the lack of contamination in downgradient monitoring wells (i.e., 41M-94-09A, 41M-94-09B, 41M-94-11X, and 41M-94-12X).

The hydrogeologic data collected at the site indicates that groundwater flow is slow, generally less than one foot per year, and therefore contaminant migration would be within a similar order of magnitude. Discussion of this information, including Fate and Transport, is presented in Section 8.0.

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- PVC STAND PIPE





LEGEND

41M-94-03X

MONITORING WELL

SA4123

SCREENED AUGER BORING
(WATER ONLY)

—

TREELINE

5

INTERPRETIVE CONCENTRATION CONTOUR

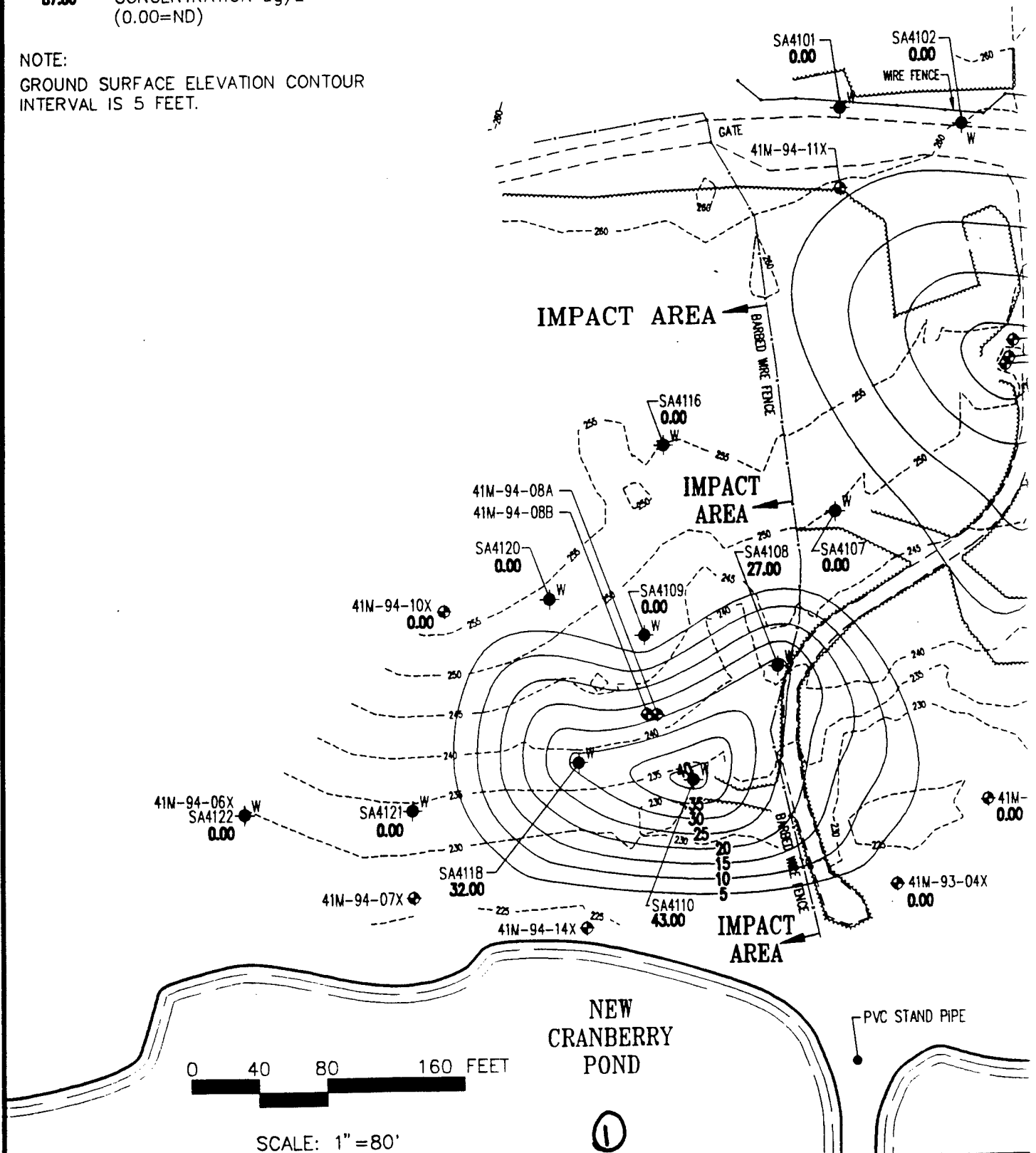
SA4104
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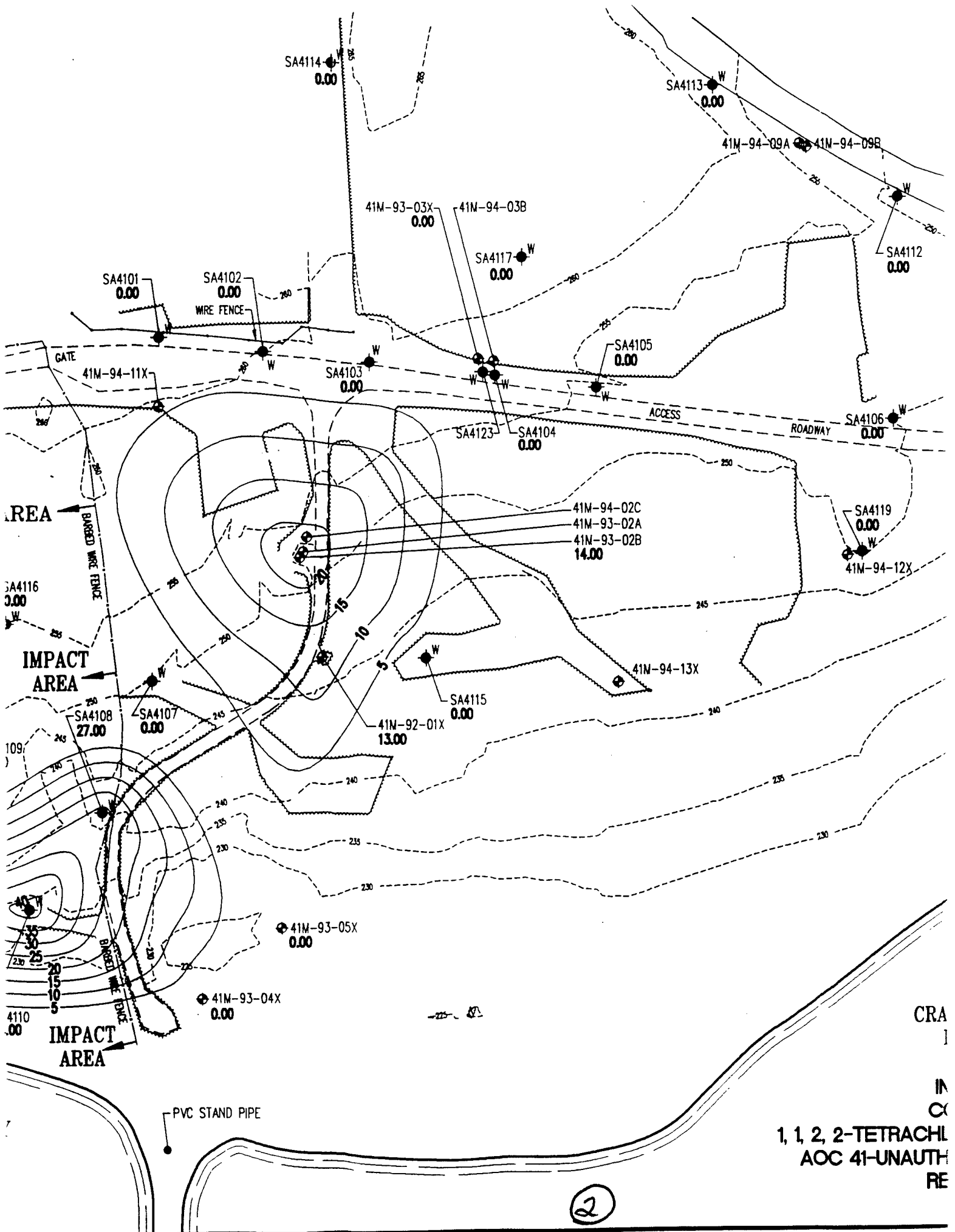
LOCATION ID
CONCENTRATION $\mu\text{g/L}$
(0.00=ND)

NOTE:

GROUND SURFACE ELEVATION CONTOUR
INTERVAL IS 5 FEET.

SA4114
0.





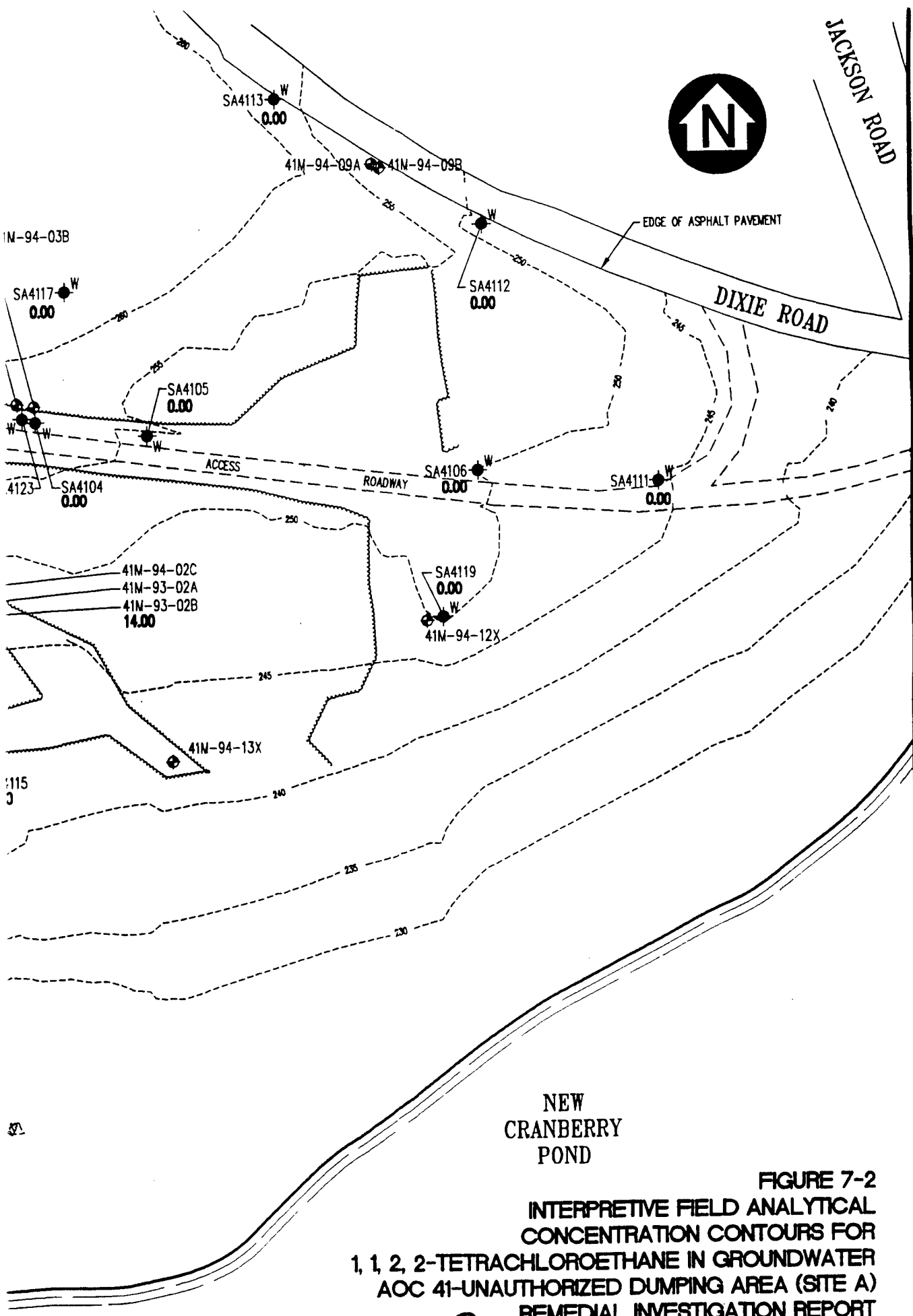


FIGURE 7-2
INTERPRETIVE FIELD ANALYTICAL
CONCENTRATION CONTOURS FOR
1, 1, 2, 2-TETRACHLOROETHANE IN GROUNDWATER
AOC 41-UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

TABLE 7-1
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN SOIL SAMPLES
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MASSACHUSETTS

	Site ID: 41E-94-03X Depth: 10 ft	Field Sample Number: EX410310	41E-94-04X 0 ft	41E-94-04X ED410400	41E-94-06X 3 ft	41E-94-09X 10 ft
			EX410400	EX410603		EX410910
PAL SEMIVOLATILE ORGANICS (µg/g)						
Benzalhyde				8.1 SD		
Methyl benzoate				.4 SD		
Palmitic acid				.54 SD		
Decane	.27 S					
Heptadecane	.14 S					
Nonane	.41 S					
Octane	.41 S					
PAL VOLATILE ORGANICS (µg/g)						
2-methylheptane	.27 S				.0031 S	
Acetic acid	.14 S					
Heptane	.14 S					
Methylcyclohexane	.14 S					
UNKNOWN GC/MS TIC (µg/g)						
UNK116	.1 S		.01 S			.4 S
UNK174						.3 S
UNK177	.1 S					
UNK201	.1 S					
UNK520				1 SD		
UNK522				.4 SD		
UNK566				.4 SD		
UNK567			.4 S			
UNK586						
UNK589						

NOTES:
D = duplicate
S = Non-target compound analyzed for and detected.

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIATION INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: 41M 92-01X Sample Date: 12/07/94 Depth: 30 Field Sample Number: MX4101X4	41M 93-02A 12/06/94 8	41M 93-02B 12/06/94 2	41M 93-03X 10/14/94 39	41M 93-05X 10/15/94 6.5	41M 93-05X 07/26/94 6.5	41M 94-02C 12/06/94 49.5	41M 94-02C MX4102C3	41M 94-02C MX4102C4	41M 94-06X 12/07/94 14.3	41M 94-06X 03/13/95 14.3	41M 94-07X 12/07/94 8	41M 94-03B 03/20/95 64
Field Sample Number: MX4101X4	MX4102A3	MX4102B3	MX4103X1	MX4105X1	MX4105X2	MX4102C3	MX4102C3	MX4102C4	MX4106C3	MX4106X4	MX4107C3	MX4103B4
PAL SEMIVOLATILE ORGANICS												
Cl7												
Cl8												
Cl9												
Cl20												
C21												
HexCB5	6	S	S	S	S	6	S					
Octadecanoic Acid, Butyl Ester												
UNKNOWN GC/MS TIC												
Unk073	6	S										
Unk078												
Unk126												
Unk532												
Unk535												
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Unk677												

TABLE 7-1
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

[illegible]

TABLE 7-2
SUMMARY OF ANALYTES DETECTED IN METHOD BLANKS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	FREQUENCY OF DETECTION	MINIMUM DETECTION	MAXIMUM DETECTION
SOIL $\mu\text{g/g}$			
VOCs			
Toluene	1:27	0.00095	0.00095
Trifluorochloromethane	5:27	0.0063	0.01
Xylene	2:27	0.0019	0.014
Acetone	1:27	0.027	0.027
Chloroform	2:27	0.001	0.002
SVOCs			
Bis(2-ethylhexyl)phthalate	2:18	0.64	2.2
4-Methyl-3-penten-2-one	2:11	0.5	0.5
Di-N-Butyl Phthalate	5:18	0.09	40
Pesticides/PCBs			
a-Chlordane	1:5	0.006	0.006
g-Chlordane	1:5	0.041	0.041
Heptachlor	1:5	0.032	0.032
AQUEOUS $\mu\text{g/L}$			
VOCs			
Toluene	1:32	0.51	0.51
Methylene Chloride	4:32	4.6	9.1
Chloroform	3:32	0.91	1.1
Acetone	3:32	16	53
Methyl Ethyl Ketone	1:32	9.5	9.5
SVOCs			
Bis(2-ethylhexyl)phthalate	5:19	5.6	200
1,2-Epoxy cyclohexane	4:19	1.0	4.0
2-Cyclohexen-1-ol	1:19	3.0	3.0
2-Cyclohexen-1-one	1:19	4.0	4.0
Mesityl Oxide	1:19	2.0	2.0
Inorganics			
Iron	1:15	56	56
Lead	1:15	3.2	3.2
Miscellaneous			
Hardness	2:6	1200	1600
TDS	2:6	11000	12000
TSS	4:14	4000	7000

TABLE 7-3
EQUIPMENT RINSATE SUMMARY
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYSES (µg/L)	FREQUENCY OF DETECTION	MINIMUM DETECTION	MAXIMUM DETECTION
<u>VOCs</u>			
1,1,1-Trichloroethane	4:6	1.8	6.8
Acetone	1:6	18	18
Methylene Chloride	2:6	2.8	4.0
Chloroform	1:6	1.3	1.3
<u>SVOCs</u>			
Di-n-butyl Phthalate	2:3	9.1	13
<u>Inorganics</u>			
Lead	3:7	1.52	3.4
Aluminum	1:5	499	499
Iron	2:5	48	1120
Manganese	2:5	3.5	30.2
Arsenic	1:5	3.8	3.8
Calcium	1:5	4790	4790
Potassium	1:5	488	488
<u>Miscellaneous</u>			
TOC	1:3	1340	1340

Notes:

VOCs = Volatile Organic Compounds

SVOCs = Semivolatile Organic Compounds

TPH = Total Petroleum Hydrocarbons

TABLE 7-4
TRIP BLANK SUMMARY
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYSES ($\mu\text{g/L}$)	FREQUENCY OF DETECTION	MINIMUM DETECTION	MAXIMUM DETECTION
VOCs			
Total Xylenes	1:42	1.9	1.9
Acetone	1:42	29	29
Methylene Chloride	8:42	2.6	17
Chloroform	1:42	0.81	0.81

Notes:

VOCs = Volatile Organic Compounds

SVOCs = Semivolatile Organic Compounds

TPH = Total Petroleum Hydrocarbons

TABLE 7-5
SOIL GAS FIELD ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

LOCATION ID	SAMPLE DEPTH	RL (ppb)	trans-1,2-DCE (ppb)	cis-1,2-DCE (ppb)	TCE (ppb)	DATE ANALYZED	COMMENTS
TS-01	5	1	<1.0	<1.0	3.9	03/30/95	Soil Vapor
TS-01	7	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-01	9	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-01	11	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-01	13	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-01	19	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-02	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-03	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-04	5	1	<1.0	<1.0	3.6	03/30/95	Soil Vapor
TS-04	10	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-04	15	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-04	20	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-05	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-06	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-07	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-08	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-09	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-10	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-11	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-12	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-13	5	1	<1.0	<1.0	<1.0	03/30/95	Soil Vapor
TS-13	5	1	<1.0	<1.0	<1.0	03/31/95	Soil Vapor

Notes:

All samples analyzed with a dilution factor of one.

Volatiles analyzed by Modified USEPA Method 8015, Solid Extraction Direct Injection (PID).

RL = Reporting Limit

ppb = parts per billion

TABLE 7-6
TERRAPROBE SOIL FIELD ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

LOCATION ID	SAMPLE DEPTH	RL (ppb)	trans- 1,2-DCE (ppb)	cis 1,2-DCE (ppb)	TCE (ppb)	DATE ANALYZED	COMMENTS
TS-01	18	1	<1.4	<1.4	<1.4	04/03/95	SOIL
TS-01	23	1	<1.3	<1.3	<1.3	04/03/95	SOIL
TS-01	30	1	<1.3	<1.3	51	03/30/95	SOIL
TS-01	35	1	<1.3	<1.3	67	03/30/95	SOIL
TS-02	30	1	<1.2	<1.2	6.4	03/31/95	SOIL
TS-02	35	1	<1.2	<1.2	1.7	03/31/95	SOIL
TS-03	30	1	2.2	<1.3	1.4	04/04/95	SOIL
TS-03	35	1	<1.3	<1.3	<1.3	04/04/95	SOIL
TS-04	18	1	<1.4	<1.4	<1.4	04/03/95	SOIL
TS-04	23	1	<1.2	<1.2	<1.2	04/03/95	SOIL
TS-04	30	1	<1.3	<1.3	180	03/30/95	SOIL
TS-04	35	1	<1.3	<1.3	64	03/30/95	SOIL
TS-05	30	1	2.2	<1.2	49	03/31/95	SOIL
TS-05	35	1	<1.2	<1.2	23	03/31/95	SOIL
TS-06	30	1	<1.4	<1.4	<1.4	03/31/95	SOIL
TS-06	35	1	<1.2	<1.2	<1.2	03/31/95	SOIL
TS-07	30	1	<1.0	<1.0	<1.0	03/31/95	SOIL
TS-07	35	1	<1.2	<1.2	23	03/31/95	SOIL
TS-10	30	1	<1.3	<1.3	<1.3	04/04/95	SOIL
TS-10	35	1	<1.3	<1.3	<1.3	04/04/95	SOIL
TS-11	30	1	<1.4	<1.4	<1.4	04/04/95	SOIL
TS-11	35	1	4.3	<1.6	4.2	04/04/95	SOIL
TS-12	30	1	2.6	<1.3	22	03/31/95	SOIL
TS-12	35	1	<1.2	<1.2	78	03/31/95	SOIL
TS-14	30	1	<1.4	<1.4	<1.4	04/03/95	SOIL
TS-14	35	1	<1.2	<1.2	7.5	04/03/95	SOIL
TS-15	30	1	9.1	<1.2	110	04/03/95	SOIL
TS-15	35	1	3.4	<1.3	77	04/03/95	SOIL
TS-16	30	1	4.5	<1.3	34	04/04/95	SOIL
TS-16	30	1	1.5	<1.0	46	04/04/95	SOIL

Notes:

All samples analyzed with a dilution factor of one.

Volatiles analyzed by Modified USEPA Method 8015, Solid Extraction Direct Injection (PID).

RL = Reporting Limit

ppb = parts per billion

TABLE 7-7
TEST PIT SOIL SAMPLE FIELD ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE (µg/L)	41E-94-01X 02 FT TP40102F	41E-94-01X 04 FT TP40104F	41E-94-01X 10 FT TP40110F	41E-94-02X 02 FT TP40202F	41E-94-02X 09 FT TP40209F	41E-94-03X 02 FT TP40302F	41E-94-03X 11 FT TP40311F	41E-94-04X 1 FT TP40401F	41E-94-04X 3 FT TP40403F	41E-94-05X 3 FT TP40503F	41E-94-05X 5 FT TP40505F	41E-94-05X 10 FT TP40510F
VINYL CHLORIDE	<4.4	<4.8	<5.4	<4.4	<5.6	<5.1	<5.7	<6.1	<4.3	<4.9	<4.2	<5.0
t-1,2-DCE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5
c-1,2-DCE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5
BENZENE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5
TRICHLOROETHENE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5
TOLUENE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5
TETRACHLOROETHENE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5
ETHYLBENZENE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5
m/p-XYLENE	<4.4	<4.8	<5.4	<4.4	<5.6	<5.1	<5.7	<6.1	<4.3	<4.9	<4.2	<5.0
o-XYLENE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5
1,1,2,2-TCA	<4.4	<4.8	<5.4	<4.4	<5.6	<5.1	<5.7	<6.1	<4.3	<4.9	<4.2	<5.0
1,2-DICHLOROBENZENE	<2.2	<2.4	<2.7	<2.2	<2.8	<2.5	<2.9	<3.0	<2.1	<2.4	<2.1	<2.5

TABLE 7-8
SOIL BORING FIELD ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	41M-94-03B 02 FT SB40302F	41M-94-03B 07 FT SB40307F	41M-94-03B 12 FT SB40312F	41M-94-03B 17 FT SB40317F	41M-94-03B 22 FT SB40322F	41M-94-03B 27 FT SB40327F	41M-94-03B 32 FT SB40332F
VINYL CHLORIDE	<4.2	<4.1	<4.3	<5.6	<6.2	<5.0	<5.2
t-1,2-DCE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	<2.6
c-1,2-DCE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	<2.6
BENZENE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	<2.6
TRICHLOROETHENE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	4.6
TOLUENE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	<2.6
TETRACHLOROETHENE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	<2.6
ETHYLBENZENE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	<2.6
m/p-XYLENE	<4.2	<4.1	<4.3	<5.6	<6.2	<5.0	<5.2
o-XYLENE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	<2.6
1,1,2,2-TCA	<4.2	<4.1	<4.3	<5.6	<6.2	<5.0	<5.2
1,2-DICHLOROBENZENE	<2.1	<2.1	<2.1	<2.8	<3.1	<2.5	<2.6

TABLE 7-8
SOIL BORING FIELD ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	41M-94-03B 37 FT SB40337F	41M-94-03B 42 FT SB40342F	41M-94-03B 47 FT SB40347F	41M-94-03B 52 FT SB40352F	41M-94-03B 57 FT SB40357F	41M-94-03B 62 FT SB40362F	41M-94-03B 67 FT SB40367F
VINYL CHLORIDE	<5.0	<5.1	<5.4	<5.1	<5.0	<5.1	<5.1
t-1,2-DCE	<2.5	<2.5	<2.7	<2.5	<2.5	<2.6	<2.6
c-1,2-DCE	<2.5	<2.5	<2.7	<2.5	<2.5	<2.6	<2.6
BENZENE	<2.5	<2.5	<2.7	<2.5	<2.5	<2.6	<2.6
TRICHLOROETHENE	5.3	8.6	<2.7	<2.5	<2.5	<2.6	<2.6
TOLUENE	<2.5	<2.5	<2.7	<2.5	<2.5	<2.6	<2.6
TETRACHLOROETHENE	<2.5	<2.5	<2.7	<2.5	<2.5	<2.6	<2.6
ETHYLBENZENE	<2.5	<2.5	<2.7	<2.5	<2.5	<2.6	<2.6
m/p-XYLENE	<5.0	<5.1	<5.4	<5.1	<5.0	<5.1	<5.1
o-XYLENE	<2.5	<2.5	<2.7	<2.5	<2.5	<2.6	<2.6
1,1,2,2-TCA	<5.0	<5.1	<5.4	<5.1	<5.0	<5.1	<5.1
1,2-DICHLOROBENZENE	<2.5	<2.5	<2.7	<2.5	<2.5	<2.6	<2.6

TABLE 7-9
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SITE ID: DEPTH: Field Sample Number:	TCLP										TCLP		TCLP		TCLP		TCLP	
	FORT DEVENS BACKGROUND CONCENTRATIONS	41E-94-01X 2 ft EX410101	41E-94-01X 2 ft EX410101	41E-94-01X 4 ft EX410103	41E-94-01X 4 ft EX410103	RI 10 ft EX410109	41E-94-01X 10 ft EX410109	41E-94-01X 10 ft EX410109	41E-94-01X 2 ft EX410201	41E-94-02X 2 ft EX410201	41E-94-02X 9 ft EX410209	41E-94-02X 9 ft EX410209	41E-94-02X 9 ft EX410209	41E-94-02X 9 ft EX410209	41E-94-02X 9 ft EX410209	41E-94-02X 9 ft EX410209	41E-94-02X 9 ft EX410209	41E-94-02X 9 ft EX410209
Aluminum	18000	6690	NA	3910	NA	19300	NA	NA	NA	2360	8430	15	NA	NA	NA	NA	NA	NA
Arsenic	19	8.83	<2.54 I	5.24	<2.54 I	13.5	<2.54 I	<2.54 I	<2.54 I	4.68	15	5.12	NA	NA	NA	NA	NA	NA
Barium	54	7.94	245	11.4	302	70.3	302	542	277	<5.18	30.7	347	NA	NA	NA	NA	NA	NA
Beryllium	0.81	<5	NA	<5	NA	0.943	NA	NA	NA	<0.5	<0.5	<0.5	NA	NA	NA	NA	NA	NA
Calcium	810	259	NA	166	NA	552	NA	NA	NA	318	1930	NA	NA	NA	NA	NA	NA	NA
Chromium	33	8.43	<6.02	5.88	<6.02	28.8	<6.02	<6.02	<6.02	<4.05	18.1	<6.02	NA	NA	NA	NA	NA	NA
Cobalt	4.7	3.07	NA	2.31	NA	10.4	NA	NA	NA	1.96	6.5	<6.02	NA	NA	NA	NA	NA	NA
Copper	13.5	6.9	NA	5.81	NA	19	NA	NA	NA	5.24	14.5	NA	NA	NA	NA	NA	NA	NA
Iron	18000	7990	NA	5840	NA	23500	NA	NA	NA	3770	15100	NA	NA	NA	NA	NA	NA	NA
Lead	48	4.2	<18.6	2.88	<18.6	12.1	<18.6	<18.6	<18.6	2.09	6.5	<18.6	NA	NA	NA	NA	NA	NA
Magnesium	5500	1390	NA	1250	NA	5630	NA	NA	NA	633	3490	NA	NA	NA	NA	NA	NA	NA
Manganese	380	81.1	NA	104	NA	412	NA	NA	NA	70.3	276	NA	NA	NA	NA	NA	NA	NA
Nickel	14.6	9.03	NA	6.19	NA	26.6	NA	NA	NA	4.97	19.5	NA	NA	NA	NA	NA	NA	NA
Potassium	2400	351	NA	555	NA	2830	NA	NA	NA	338	1300	NA	NA	NA	NA	NA	NA	NA
Sodium	234	314	NA	300	NA	513	NA	NA	NA	344	505	NA	NA	NA	NA	NA	NA	NA
Vanadium	32.3	7.8	NA	6.5	NA	29.2	NA	NA	NA	<3.39	15	NA	NA	NA	NA	NA	NA	NA
Zinc	43.9	17.4	NA	14.7	NA	56.2	NA	NA	NA	<8.03	34.9	NA	NA	NA	NA	NA	NA	NA
PAL SEMIVOLATILE ORGANICS (µg/g)																		
Acenaphthylene		<0.33	NA	<0.33	NA	<0.33	NA	NA	NA	<0.33	<0.33	<0.33	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene		<21	NA	<21	NA	<21	NA	NA	NA	<21	<21	<21	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene		<0.66	NA	<0.66	NA	<0.66	NA	NA	NA	<0.66	<0.66	<0.66	NA	NA	NA	NA	NA	NA
*Bis (2-ethylhexyl) Phthalate		<62	NA	<62	NA	<62	NA	NA	NA	<62	<62	<62	NA	NA	NA	NA	NA	NA
Chrysene		<12	NA	<12	NA	<12	NA	NA	NA	<12	<12	<12	NA	NA	NA	NA	NA	NA
*Di-n-butyl Phthalate		<0.61	NA	<0.61	NA	<0.61	NA	NA	NA	<0.61	<0.61	<0.61	NA	NA	NA	NA	NA	NA
Fluoranthene		<0.68	NA	<0.68	NA	<0.68	NA	NA	NA	<0.68	<0.68	<0.68	NA	NA	NA	NA	NA	NA
Phenanthrene		<0.33	NA	<0.33	NA	<0.33	NA	NA	NA	<0.33	<0.33	<0.33	NA	NA	NA	NA	NA	NA
Pyrene		<0.33	NA	<0.33	NA	<0.33	NA	NA	NA	<0.33	<0.33	<0.33	NA	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/g)																		
1,1,2,2-tetrachloroethane		<0.024	NA	<0.024	NA	<0.024	NA	NA	NA	<0.024	<0.024	<0.024	NA	NA	NA	NA	NA	NA
*Acetone		<0.17	NA	<0.17	NA	<0.17	NA	NA	NA	<0.17	<0.17	<0.17	NA	NA	NA	NA	NA	NA
*Methylene Chloride		<0.12	NA	<0.12	NA	<0.12	NA	NA	NA	<0.12	<0.12	<0.12	NA	NA	NA	NA	NA	NA
Toluene		<0.0078	NA	<0.0078	NA	<0.0078	NA	NA	NA	<0.0078	<0.0078	<0.0078	NA	NA	NA	NA	NA	NA
Trichlorofluoromethane		0.016	NA	0.017*	NA	0.0084*	NA	0.0084*	NA	0.0059*	0.011*	<0.0078	NA	NA	NA	NA	NA	NA
OTHER (µg/g)																		
Total Organic Carbon		2870	NA	1110	NA	3730	NA	NA	NA	1330	1970	<28.3	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons		<28.2	NA	<28.1	NA	<28.1	NA	NA	NA	<28.5	<28.3	<28.3	NA	NA	NA	NA	NA	NA

TABLE 7-9
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SITE ID: DEPTH: Field Sample Number:	FORT DEVENS BACKGROUND CONCENTRATIONS	TCIP			RI		TCIP			TCIP		
		41E-94-03X 2 ft EX410301	41E-94-03X 11 ft EX410310	41E-94-04X 1 ft EX410400	41E-94-04X 1 ft (DUP) ED410400	41E-94-04 1 ft EX410400	41E-94-04X 1 ft ED410400	41E-94-04X 3 ft EX410402	41E-94-04X 3 ft EX410402	41E-94-05X 3 ft EX410502		
Aluminum	18000	31400	NA	8240	8940 D	NA	NA	4410	NA	3400		
Arsenic	19	12.9	2.54 T	6.41	5 D	NA	<2.45 D	6.33	<2.45	5.5		
Barium	54	92.2	506	20.1	20.4 D	260	285 D	7.88	277	14.4		
Beryllium	0.81	1.76	NA	0.777	<5 D	NA	NA	<5	NA	<5		
Calcium	810	459	NA	2010	194 D	NA	NA	263	NA	204		
Chromium	33	35.4	<6.02	48.3	7.52 D	NA	<6.02 D	6	NA	5.05		
Cobalt	4.7	9.33	NA	22.9	12.8 D	NA	NA	2.25	NA	<1.42		
Copper	13.5	20.4	NA	8.24	7.76 D	NA	NA	5.87	NA	8.9		
Iron	18000	30400	NA	37700	28400 D	NA	NA	6750	NA	4710		
Lead	48	11	<18.6	11.1	8.01 D	NA	<18.6 D	1.81	<18.6	43		
Magnesium	5500	6640	NA	1000	943 D	NA	NA	1160	NA	616		
Manganese	380	280	NA	625	509 D	NA	NA	86	NA	75.3		
Nickel	14.6	25.7	NA	38.8	7.49 D	NA	NA	6.49	NA	3.93		
Potassium	2400	4410	NA	6670	272 D	NA	NA	372	NA	380		
Sodium	234	532	NA	691	480 D	NA	NA	326	NA	344		
Vanadium	32.3	48.4	NA	56.5	9.69 D	NA	NA	6.56	NA	7.77		
Zinc	43.9	65.9	NA	90.8	18.7 D	NA	NA	13.8	NA	95.8		
PAL SEMIVOLATILE ORGANICS (µg/g)												
Aceanaphthylene		<033	NA	<033	<033 D	NA	NA	<033	NA	0.048		
Benzo[b]Fluoranthene		<21	NA	<21	<21 D	NA	NA	<21	NA	0.3		
Benzo[k]Fluoranthene		<066	NA	<066	<066 D	NA	NA	<066	NA	0.2		
*Bis (2-ethylhexyl) Phthalate		<62	NA	<62	<62 D	NA	NA	<62	NA	<62		
Chrysene		<12	NA	<12	<12 D	NA	NA	<12	NA	0.24		
*Di-n-butyl Phthalate		<061	NA	<061	<061 D	NA	NA	<061	NA	<061		
Fluoranthene		<068	NA	<068	38 D	NA	NA	<068	NA	0.26		
Phenanthrene		<033	NA	<033	17 D	NA	NA	<033	NA	0.066		
Pyrene		<033	NA	<033	37 D	NA	NA	<033	NA	0.28		
PAL VOLATILE ORGANICS (µg/g)												
1,1,2,2-tetrachloroethane		<0024	NA	<0024	<0024 D	NA	NA	<0024	NA	<0024		
*Acetone		<017	NA	<017	<017 D	NA	NA	<017	NA	<017		
*Methylene Chloride		<012	NA	<012	<012 D	NA	NA	<012	NA	<012		
Toluene		<00078	NA	<00078	<00078 D	NA	NA	<00078	NA	<00078		
Trichlorofluoromethane		0.0059	NA	0.013 B*	<0059 D	NA	NA	<0059	NA	<0059		
OTHER (µg/g)												
Total Organic Carbon		3720	NA	3020	12300 D	NA	NA	1980	NA	5400		
Total Petroleum Hydrocarbons		<8.1	NA	<28.3	<28.5 D	NA	NA	<21.1	NA	1450		

TABLE 7-9
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SITE ID: DEPTH: Field Sample Number:	FORT DEVENS BACKGROUND CONCENTRATIONS	TCLP			RI		TCLP			TCLP		
		41E-94-05X 3 ft ED410402	41E-94-05X 3 ft ED410502	41E-94-05X 5 ft EX410504	41E-94-05X 5 ft ED410504	41E-94-05X 10 ft EX410509	41E-94-05X 10 ft EX410509	41E-94-05X 10 ft EX410509	41E-94-06X 3 ft EX410603			
Aluminum	18000	4190 D	NA	2540	2650 D	NA	2140	NA	2530			
Arsenic	19	5 D	<2.45 D	3.8	5.2 D	<2.45	3.8	<2.45	3.96			
Barium	54	12.1 D	252	6.71	7.37 D	319	<5.18	301	10.8			
Beryllium	0.81	<0.5 D	NA	<0.5	<5 D	NA	<0.5	NA	<5			
Calcium	810	370 D	NA	165	166 D	NA	203	NA	298			
Chromium	33	<4.05 D	<6.02	<4.05	<4.05 D	<6.02	<4.05	<6.02	<4.05			
Cobalt	4.7	1.69 D	NA	<1.42	1.66 D	NA	<1.42	NA	1.9			
Copper	13.5	6.31 D	NA	3.91	3.52 D	NA	3.47	NA	3.32			
Iron	18000	4730 D	NA	3870	3930 D	NA	3890	NA	4470			
Lead	48	18 D	45.9	2.14	1.96 D	<18.6	3.37	<18.6	2.2			
Magnesium	5500	752 D	NA	875	771 D	NA	757	NA	719			
Manganese	380	90 D	NA	62.5	67.9 D	NA	58.9	NA	158			
Nickel	14.6	4.16 D	NA	4.64	4.3 D	NA	3.1	NA	4.52			
Potassium	2400	477 D	NA	463	529 D	NA	501	NA	422			
Sodium	234	310 D	NA	305	372 D	NA	356	NA	<100			
Vanadium	32.3	9.24 D	NA	3.96	4.63 D	NA	4.5	NA	4.29			
Zinc	43.9	40.4 D	NA	15.3	13.7 D	NA	<8.03	NA	10.1			
PAL SEMIVOLATILE ORGANICS (µg/g)												
Acenaphthylene		<0.33 D	NA	<0.33	<0.33 D	NA	<0.33	NA	<0.33			
Benzo[b]Fluoranthene		<21 D	NA	<21	<21 D	NA	<0.21	NA	<21			
Benzo[k]Fluoranthene		.12 D	NA	<0.66	<0.66 D	NA	<0.66	NA	<0.66			
*Bis (2-ethylhexyl) Phthalate		<62 D	NA	<62	<62 D	NA	<62	NA	<62			
Chrysene		.16 D	NA	<12	<12 D	NA	<12	NA	<12			
*Di-n-butyl Phthalate		<0.61 D	NA	<0.61	<0.61 D	NA	<0.61	NA	<0.61			
Fluoranthene		.19 D	NA	<0.68	<0.68 D	NA	<0.68	NA	<0.68			
Phenanthrene		.044 D	NA	<0.33	<0.33 D	NA	<0.33	NA	<0.33			
Pyrene		.16 D	NA	<0.33	<0.33 D	NA	<0.33	NA	<0.33			
PAL VOLATILE ORGANICS (µg/g)												
1,1,2,2-tetrachloroethane		.065 D	NA	<0.024	<0.024 D	NA	<0.024	NA	<0.024			
Acetone		.1 D	NA	<0.17	<0.17 D	NA	<0.17	NA	<0.17			
Methylene Chloride		.052 D	NA	<0.12	<0.12 D	NA	<0.12	NA	<0.12			
Toluene		.023 D*	NA	<0.0078	<0.0078 D	NA	<0.0078	NA	<0.0078			
*Trichlorofluoromethane		.02 D	NA	<0.059	<0.059 D	NA	<0.059	NA	<0.059			
OTHER (µg/g)												
Total Organic Carbon		7080 D	NA	697	613 D	NA	1000	NA	2170			
Total Petroleum Hydrocarbons		53.8 D	NA	<28.5	<28.5 D	NA	<28.3	NA	<28.3			

TABLE 7-9
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Field Sample Number:	SITE ID: DEPTH:	FORT DEVENS BACKGROUND CONCENTRATIONS	RI										SI	
			41E-94-06X 9 ft EX410610	41E-94-07X 4 ft EX410704	41E-94-07X 10 ft EX410710	41E-94-08X 4 ft EX410804	41E-94-08X 10 ft EX410810	41E-94-08X 12 ft EX410812	41E-94-09X 4 ft EX410904	41E-94-09X 9 ft EX410910	41E-94-09X 9 ft ED410910	41M-92-01X 26-28 ft BX410126		
Aluminum		18000	2620	2450	2260	2370	2460	3050	3040	2950	2880 D	NA		
Arsenic		19	3.57	3.97	3.69	3.15	6.34	4.28	3.76	3.81	3.73 D	NA		
Barium		54	9.48	7.22	8.82	6.94	8.08	11.5	10.4	7.54	7.84 D	NA		
Beryllium		0.81	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5 D	NA		
Calcium		810	374	292	278	149	436	276	229	336	299 D	NA		
Chromium		33	<4.05	<4.05	<4.05	<4.05	<4.05	6.44	5.87	<4.05	<4.05 D	NA		
Cobalt		4.7	1.84	<1.42	1.79	<1.42	<1.42	2.02	2.26	2.14	1.72 D	NA		
Copper		13.5	2.84	2.67	3.86	2.83	3.1	3.41	3.57	3.33	3.64 D	NA		
Iron		18000	4440	4270	3950	4810	4550	4540	5280	4330	4150 D	NA		
Lead		48	1.96	1.99	1.92	3.28	2.64	2.6	2.54	2.33	2.45 D	NA		
Magnesium		5500	890	790	802	707	855	1150	1100	879	802 D	NA		
Manganese		380	63.5	61.2	61.3	65.7	67.7	61.3	80.3	77.7	60.1 D	NA		
Nickel		14.6	3.84	4.26	3.84	2.89	2.4	4.49	5.29	4.67	4.27 D	NA		
Potassium		2400	517	432	523	492	478	664	614	466	473 D	NA		
Sodium		234	<100	<100	369	<100	128	<100	<100	<100	<100 D	NA		
Vanadium		32.3	4.74	3.99	4.55	4.19	4.65	5.61	5.43	4.43	4.27 D	NA		
Zinc		43.9	10.8	10.3	11	9.67	10.6	10.9	12.3	10.2	9.98 D	NA		
PAL SEMIVOLATILE ORGANICS (µg/g)														
Acenaphthylene			<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33 D	NA		
Benzo[b]fluoranthene			<.21	<.21	<.21	<.21	<.21	<.21	<.21	<.21	<.21 D	NA		
Benzo[k]fluoranthene			<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66 D	NA		
*Bis (2-ethylhexyl) Phthalate			<.62	<.62	1.3	<.62	<.62	<.62	<.62	<.62	<.62 D	NA		
Chrysene			<.12	<.12	<.12	<.12	<.12	<.12	<.12	<.12	<.12 D	NA		
*Di-n-butyl Phthalate			<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61 D	NA		
Fluoranthene			<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68 D	NA		
Phenanthrene			<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33 D	NA		
Pyrene			<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33 D	NA		
PAL VOLATILE ORGANICS (µg/g)														
1,1,1,1,2,2-tetrachloroethane			<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	NA		
*Acetone			<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017	<.017 D	NA		
*Methylene Chloride			<.012	<.012	<.012	<.012	<.012	<.012	<.012	<.012	<.012 D	NA		
Toluene			<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	NA		
*Trichlorofluoromethane			<0.059	<0.059	<0.059	<0.059	<0.059	<0.059	<0.059	<0.059	<0.059 D	NA		
OTHER (µg/g)														
Total Organic Carbon			2660	703	1200	738	780	668	764	811	948 D	199		
Total Petroleum Hydrocarbons			<.8	<.78	<.78	<.78	<.8	<.78	<.78	<.78	<.78 D	NA		

TABLE 7-9
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

SITE ID: DEPTH: Field Sample Number	FORT DEVENS BACKGROUND CONCENTRATIONS	SSI									
		41M-93-02B 2-4 ft BX410204	41M-93-02B 4-6 ft BX410206	41M-93-02B 30-32 ft BX410232	41M-93-02B 30-32 ft BX410232	41M-93-03X 45-47 ft BX410345	41M-93-04X 5 ft BX410405	41M-93-05X 5 ft BX410505	41M-94-02C 29-31 ft BX410239	41M-94-07X 5-7 ft BX410705	41M-94-08A 24-26 ft BX410825
Aluminum	18000	14200	37600	6290	6600 D	4080	NA	NA	NA	NA	NA
Arsenic	19	14	25	24	18 D	13	NA	NA	NA	NA	NA
Barium	54	80.5	224	29.7	29.3 D	23.4	NA	NA	NA	NA	NA
Beryllium	0.81	<5	1.95	<0.5	<0.5 D	<0.5	NA	NA	NA	NA	NA
Calcium	810	1370	2280	1970	2080 D	1200	NA	NA	NA	NA	NA
Chromium	33	24.8	70.3	15.6	17.7 D	11.7	NA	NA	NA	NA	NA
Cobalt	4.7	9.78	17	7.09	6.44 D	5.28	NA	NA	NA	NA	NA
Copper	13.5	16.1	40.4	10.8	11.1 D	7.39	NA	NA	NA	NA	NA
Iron	18000	24100	50300	11700	12400 D	7900	NA	NA	NA	NA	NA
Lead	48	9.5	22	6.05	7.93 D	3.94	NA	NA	NA	NA	NA
Magnesium	5500	5500	12700	2700	2900 D	2050	NA	NA	NA	NA	NA
Manganese	380	392	541	384	188 D	147	NA	NA	NA	NA	NA
Nickel	14.6	19.5	51.5	16.3	16.9 D	13.1	NA	NA	NA	NA	NA
Potassium	2400	4140	11500	1380	1370 D	859	NA	NA	NA	NA	NA
Sodium	234	449	669	458	497 D	388	NA	NA	NA	NA	NA
Vanadium	32.3	33.9	87.7	12.1	12.4 D	8.28	NA	NA	NA	NA	NA
Zinc	43.9	66.3	148	28	34.3 D	22.4	NA	NA	NA	NA	NA
PAL SEMIVOLATILE ORGANICS (µg/g)											
Acenaphthylene		<0.33	<0.33	<0.33	<0.33	<0.33	NA	NA	NA	NA	NA
Benzo[b]fluoranthene		<21	<21	<21	<21	<21	NA	NA	NA	NA	NA
Benzo[k]fluoranthene		<0.66	<0.66	<0.66	<0.66	<0.66	NA	NA	NA	NA	NA
*Bis(2-ethylhexyl) Phthalate		<62	<62	<62	<62	<62	NA	NA	NA	NA	NA
Chrysene		<12	<12	<12	<12	<12	NA	NA	NA	NA	NA
*Di-n-butyl Phthalate		<0.61	<0.61	<0.61	<0.61	<0.61	NA	NA	NA	NA	NA
Fluoranthene		<0.68	<0.68	<0.68	<0.68	<0.68	NA	NA	NA	NA	NA
Phenanthrene		<0.33	<0.33	<0.33	<0.33	<0.33	NA	NA	NA	NA	NA
Pyrene		<0.33	<0.33	<0.33	<0.33	<0.33	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/g)											
1,1,2,2-tetrachloroethane		<0.024	<0.024	<0.024	<0.024	<0.024	NA	NA	NA	NA	NA
*Acetone		<0.17	<0.17	<0.17	<0.17	<0.17	NA	NA	NA	NA	NA
*Methylene Chloride		<0.12	<0.12	<0.12	<0.12	<0.12	NA	NA	NA	NA	NA
Toluene		<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	NA	NA	NA	NA	NA
*Trichlorofluoromethane		<0.059	<0.059	<0.059	<0.059	<0.059	NA	NA	NA	NA	NA
OTHER (µg/g)											
Total Organic Carbon		NA	NA	360	700	659	643	745	3900	4580	2430
Total Petroleum Hydrocarbons		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 7-9
SOIL BORING OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Field Sample Number	SITE ID: DEPTH	FORT DEVENS BACKGROUND CONCENTRATIONS	SSI							
			41M-94-08B 39-41 ft BX418B40	41M-94-09A 35-37 ft BX419A35	41M-94-09B 40-42 ft BX419B40	41M-94-10X 40-42 ft BX411040	41M-94-11X 34-36 ft BX411135	41M-94-12X 40-42 ft BX411240	41M-94-13X 19-21 ft BX411320	41M-94-14X 4-6 ft BX411404
Aluminum		18000	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic		19	NA	NA	NA	NA	NA	NA	NA	NA
Barium		54	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium		0.81	NA	NA	NA	NA	NA	NA	NA	NA
Calcium		810	NA	NA	NA	NA	NA	NA	NA	NA
Chromium		33	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt		4.7	NA	NA	NA	NA	NA	NA	NA	NA
Copper		13.5	NA	NA	NA	NA	NA	NA	NA	NA
Iron		18000	NA	NA	NA	NA	NA	NA	NA	NA
Lead		48	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium		5500	NA	NA	NA	NA	NA	NA	NA	NA
Manganese		380	NA	NA	NA	NA	NA	NA	NA	NA
Nickel		14.6	NA	NA	NA	NA	NA	NA	NA	NA
Potassium		2400	NA	NA	NA	NA	NA	NA	NA	NA
Sodium		234	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium		32.3	NA	NA	NA	NA	NA	NA	NA	NA
Zinc		43.9	NA	NA	NA	NA	NA	NA	NA	NA
PAL SEMIVOLATILE ORGANICS (µg/g)										
Acenaphthylene			NA	NA	NA	NA	NA	NA	NA	NA
Benzo[b]fluoranthene			NA	NA	NA	NA	NA	NA	NA	NA
Benzo[k]fluoranthene			NA	NA	NA	NA	NA	NA	NA	NA
*Bis (2-ethylhexyl) Phthalate			NA	NA	NA	NA	NA	NA	NA	NA
Chrysene			NA	NA	NA	NA	NA	NA	NA	NA
*Di-n-butyl Phthalate			NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene			NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene			NA	NA	NA	NA	NA	NA	NA	NA
Pyrene			NA	NA	NA	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/g)										
1,1,2,2-tetrachloroethane			NA	NA	NA	NA	NA	NA	NA	NA
*Acetone			NA	NA	NA	NA	NA	NA	NA	NA
*Methylene Chloride			NA	NA	NA	NA	NA	NA	NA	NA
Toluene			NA	NA	NA	NA	NA	NA	NA	NA
*Trichlorofluoromethane			NA	NA	NA	NA	NA	NA	NA	NA
OTHER (µg/g)										
Total Organic Carbon			2540	1900	1880	1530	1070	1590	1290	1180
Total Petroleum Hydrocarbons			NA	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SCREENED AUGER AND EXISTING MONITORING WELL RESULTS
AOC 41 UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE ($\mu\text{g/L}$)	41M-92-01X MW401X2W	41M-93-02A MW402AXW	41M-93-02B MW402B2W	41M-93-03X MW40300W	41M-93-04X MW404XXW	41M-93-05X MW405XXW	SA4101 38 FT SA40138W
VINYL CHLORIDE	<4.0	<4.0	<8.0	<100	<4.0	<4.0	<4.0
t-1,2-DCE	<2.0	<2.0	<4.0	<50	<2.0	<2.0	<2.0
c-1,2-DCE	<2.0	<2.0	<4.0	<50	<2.0	<2.0	<2.0
BENZENE	<2.0	<2.0	<4.0	<50	<2.0	<2.0	<2.0
TRICHLOROETHENE	16	28	23	450	<2.0	<2.0	<2.0
TOLUENE	<2.0	<2.0	<4.0	<50	<2.0	<2.0	<2.0
TETRACHLOROETHENE	<2.0	<2.0	<4.0	<50	<2.0	<2.0	<2.0
ETHYLBENZENE	<2.0	<2.0	<4.0	<50	<2.0	<2.0	<2.0
m/p-XYLENE	<4.0	<4.0	<8.0	<100	<4.0	<4.0	<4.0
o-XYLENE	<2.0	<2.0	<4.0	<50	<2.0	<2.0	<2.0
1,1,2,2-TCA	13	9.5	14	<100	<4.0	<4.0	<4.0
1,2-DICHLOROBENZENE	<2.0	<2.0	<4.0	<50	<2.0	<2.0	<2.0

TABLE 7-10
SCREENED AUGER AND EXISTING MONITORING WELL RESULTS
AOC 41 UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE ($\mu\text{g/L}$)	SA4102 41 FT SA40241W	SA4103 37 FT SA40337W	SA4104 37 FT SA40437W	SA4105 40 FT SA40540W	SA4106 39 FT SA40639W	SA4107 35 FT SA40735W	SA4108 19 FT SA40819W
VINYL CHLORIDE	<40	<4.0	<100	<20	<4.0	<20	<4.0
t-1,2-DCE	<20	<2.0	<50	<10	<2.0	<10	<2.0
c-1,2-DCE	<20	<2.0	<50	<10	<2.0	<10	2.5
BENZENE	<20	<2.0	<50	<10	<2.0	<10	<2.0
TRICHLOROETHENE	87	30	496	48	6.3	16	37
TOLUENE	<20	<2.0	<50	<10	<2.0	<10	<2.0
TETRACHLOROETHENE	<20	<2.0	<50	<10	<2.0	<10	<2.0
ETHYLBENZENE	<20	<2.0	<50	<10	<2.0	<10	<2.0
m/p-XYLENE	<40	<4.0	<100	<20	<4.0	<20	<4.0
o-XYLENE	<20	<2.0	<50	<10	<2.0	<10	<2.0
1,1,2,2-TCA	<40	<4.0	<100	<20	<4.0	<20	27
1,2-DICHLOROBENZENE	<20	<2.0	<50	<10	<2.0	<10	<2.0

TABLE 7-10
SCREENED AUGER AND EXISTING MONITORING WELL RESULTS
AOC 41 UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE ($\mu\text{g/L}$)	SA4109 26 FT SA40926W	SA4110 19 FT SA41019W	SA4111 36 FT SA41136W	SA4112 38 FT SA41238W	SA4113 40 FT SA41340W	SA4114 44 FT SA41444W	SA4115 25 FT SA41525W
VINYL CHLORIDE	<40	<40	<4.0	<4.0	<4.0	<4.0	<4.0
t-1,2-DCE	<20	<20	<2.0	<2.0	<2.0	<2.0	<2.0
c-1,2-DCE	<20	<20	<2.0	<2.0	<2.0	<2.0	<2.0
BENZENE	<20	<20	<2.0	<2.0	<2.0	<2.0	<2.0
TRICHLOROETHENE	48	54	<2.0	<2.0	<2.0	<2.0	<2.0
TOLUENE	<20	<20	<2.0	<2.0	<2.0	<2.0	<2.0
TETRACHLOROETHENE	<20	<20	<2.0	<2.0	<2.0	<2.0	<2.0
ETHYLBENZENE	<20	<20	<2.0	<2.0	<2.0	<2.0	<2.0
m/p-XYLENE	<40	<40	<4.0	<4.0	<4.0	<4.0	<4.0
o-XYLENE	<20	<20	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2,2-TCA	<40	43	<4.0	<4.0	<4.0	<4.0	<4.0
1,2-DICHLOROBENZENE	<20	<20	<2.0	<2.0	<2.0	<2.0	<2.0

TABLE 7-10
SCREENED AUGER AND EXISTING MONITORING WELL RESULTS
AOC 41 UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE ($\mu\text{g/L}$)	SA4116 40 FT SA41640W	SA4117 45 FT SA41745W	SA4118 24 FT SA41824W	SA4119 45 FT SA41945W	SA4120 38 FT SA42038W	SA4121 19 FT SA42119W	SA4122 13 FT SA42213W
VINYL CHLORIDE	<4.0	<4.0	<20	<4.0	<4.0	<40	<4.0
t-1,2-DCE	<2.0	<2.0	<10	<2.0	<2.0	<20	<2.0
c-1,2-DCE	<2.0	<2.0	21	<2.0	<2.0	<20	<2.0
BENZENE	<2.0	<2.0	<10	<2.0	<2.0	<20	<2.0
TRICHLOROETHENE	<2.0	<2.0	49	<2.0	<2.0	45	<2.0
TOLUENE	<2.0	<2.0	<10	<2.0	<2.0	<20	<2.0
TETRACHLOROETHENE	<2.0	<2.0	<10	<2.0	<2.0	<20	<2.0
ETHYLBENZENE	<2.0	<2.0	<10	<2.0	<2.0	<20	<2.0
m/p-XYLENE	<4.0	<4.0	<20	<4.0	<4.0	<40	<4.0
o-XYLENE	<2.0	<2.0	<10	<2.0	<2.0	<20	<2.0
1,1,2,2-TCA	<4.0	<4.0	32	<4.0	<4.0	<40	<4.0
1,2-DICHLOROBENZENE	<2.0	<2.0	<10	<2.0	<2.0	<20	<2.0

TABLE 7-10
SCREENED AUGER AND EXISTING MONITORING WELL RESULTS
AOC 41 UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE ($\mu\text{g/L}$)	SA4123 50 FT SA42350W	SA4123 55 FT SA42355W	SA4123 60 FT SA42360W	SA4123 65 FT SA42365W	SA4123 70 FT SA42370W
VINYL CHLORIDE	<4.0	<4.0	<4.0	<4.0	<4.0
t-1,2-DCE	<2.0	<2.0	<2.0	<2.0	<2.0
c-1,2-DCE	<2.0	<2.0	<2.0	<2.0	<2.0
BENZENE	<2.0	<2.0	<2.0	<2.0	<2.0
TRICHLOROETHENE	<2.0	<2.0	<2.0	<2.0	<2.0
TOLUENE	<2.0	<2.0	<2.0	<2.0	<2.0
TETRACHLOROETHENE	<2.0	<2.0	<2.0	<2.0	<2.0
ETHYLBENZENE	<2.0	<2.0	<2.0	<2.0	<2.0
m/p-XYLENE	<4.0	<4.0	<4.0	<4.0	<4.0
o-XYLENE	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2,2-TCA	<4.0	<4.0	<4.0	<4.0	<4.0
1,2-DICHLOROBENZENE	<2.0	<2.0	<2.0	<2.0	<2.0

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIATION INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Field Sample Number (µg/L)	ROUND 1		ROUND 2		ROUND 3		ROUND 4	
	41D-92-03X 08/10/92 DX410300	41D-92-03X 08/10/92 DX410400	41D-92-03X 08/10/92 DX410500	41D-92-03X 08/10/92 DX410600	41M-92-01X 01/07/93 MX4101X1	41M-92-01X 01/07/93 MX4101X2	41M-92-01X 01/07/93 MX4101X3	41M-92-01X 01/07/93 MX4101X2
Port Devens Background Concentrations	NA 12100	NA 347 100000	NA 178 100000	NA 153 100000	NA 2120 10000	NA 2120 10000	NA 2120 10000	NA 2120 10000
PAL CATIONS/ANIONS (µg/L)								
Chloride	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
PAL METALS (µg/L)								
Aluminum	6870	53700.0	13800.0	34700.0	4900.0	43.0	302	32800
Antimony	3.03	<3.03	<3.03	<3.03	<3.03	<3.03	<3.03	<3.03
Arsenic	10.5	37.7	8.64	80.3	38.5	39.2	4.26	3.44
Barium	39.6	199	47.0	22.7	264	228	5	36.6
Beryllium	5	<5.0	<5.0	<5.0	<5.0	<5.0	5	461
Cadmium	14700	49800.0	5500.0	21000.0	13500.0	11600	3370	39200
Chromium	14.7	58.5	15.5	<6.0	149	38.9	6.02	149
Cobalt	25	<25.0	<25.0	<25.0	44.4	25	25	85.9
Copper	8.09	46.1	8.88	<8.09	93.7	72.9	8.09	147
Iron	9100	61100.0	13600.0	29000.0	110000	74000	333	110000
Lead	4.25	47.3	10.6	6.72	44.6	42.2	1.26	13.2
Magnesium	3460	18800.0	35400.0	16200.0	15700.0	17100	1420	13200
Manganese	291	11500.0	239.0	232.0	26300	893	574	220000
Mercury	0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243
Nickel	34.3	64.5	<34.3	<34.3	178	113	34.3	34.3
Potassium	2370	12500.0	5190.0	34300.0	18500	35100	2610	1000
Silver	4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
Sodium	18000	56100.0	22700.0	22500.0	21400.0	89340	6640	9710
Vanadium	11	79.4	30.4	<11.0	119	102	11	147
Zinc	21.1	144.0	38.0	<21.1	267	219	21.1	466
PAL PESTICIDES (µg/L)								
Endrin	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024
PAL EXPLOSIVES (µg/L)								
Nitroglycerin	<10	<10	<10	<10	<10	<10	<10	<10
PAL SEMI-VOLATILE ORGANICS (µg/L)								
Bar (2-ethylhexyl) Phosphate	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
PAL VOLATILE ORGANICS (µg/L)								
1,2-dichloroethane (cis And Trans Isomers)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2,2-tetrachloroethane	<0.84	<0.84	<0.84	<0.84	<0.84	<0.84	<0.84	<0.84
Carbon Disulfide	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloroform	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methylene Chloride	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3
Methyl Ethyl Ketone / 2-butanone	<6.4	<6.4	<6.4	<6.4	<6.4	<6.4	<6.4	<6.4
Tetrachloroethylene / Tetrachloroethane	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
Toluene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethylene / Trichloroethane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
WATER QUALITY PARAMETERS (µg/L)								
Alkalinity	136000	14000	14000	11000	39000	NA	NA	NA
Nitrate - non Specific	25.5	<10.0	<10.0	<10.0	46.7	NA	NA	NA
Nitrogen By Kjeldahl Method	619	210	1490	1810	NA	NA	NA	NA
Total Dissolved Solids	135000	16400	9200	10600	NA	NA	NA	NA
Total Hardness	2020000	392000	180000	172000	1870000	2180000	NA	1600000
Total Suspended Solids								

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Concentrations	ROUND 3		ROUND 4		ROUND 3		ROUND 4		ROUND 3		ROUND 4		ROUND 3		ROUND 4	
	41M-93-02A 10/15/93 27 MD4102A1	41M-93-02A 07/26/94 27 MX4102A2	41M-93-02B 10/15/93 27 MX4102B1	41M-93-02B 10/15/93 27 MX4102B1	41M-93-02B 10/15/93 27 MX4102B2	41M-93-02B 07/26/94 27 MX4102B2	41M-93-02B 10/15/93 27 MX4102B1	41M-93-02B 07/26/94 27 MX4102B2	41M-93-03X 10/14/93 39 MX4103X1	41M-93-03X 10/14/93 39 MX4103X1	41M-93-03X 10/14/93 39 MD4103X1	41M-93-03X 10/14/93 39 MD4103X1	41M-93-03X 10/14/93 39 MD4103X1	41M-93-03X 10/14/93 39 MD4103X1	41M-93-03X 10/14/93 39 MD4103X1	
PAL CATIONS/ANIONS (µg/L)																
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL METALS (µg/L)																
Aluminum	6870	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Antimony	3.03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Arsenic	10.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Barium	39.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Beryllium	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Calcium	14700	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Chromium	14.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Cobalt	25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Copper	8.09	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Iron	9100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Lead	4.25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Magnesium	3480	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Manganese	291	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Mercury	0.243	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Nickel	34.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Potassium	2370	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Silver	4.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Sodium	10800	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Vanadium	11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Zinc	21.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL PESTICIDES (µg/L)																
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL EXPLOSIVES (µg/L)																
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL SEMIVOLATILE ORGANICS (µg/L)																
Bis (2-ethylhexyl) Phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL VOLATILE ORGANICS (µg/L)																
1,2-dichloroethylenes (Cis And Trans Isomers)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Xylenes	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
1,1,2,2-tetrachloroethane	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Carbon Disulfide	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Carbon Tetrachloride	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
*Chloroform	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
*Methylene Chloride	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	
Methyl Ethyl Ketone / 2-butanone	83	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	
Tetrachloroethylene / Tetrachloroethene	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	
*Toluene	41	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Benzene	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Trichloroethylene / TriChloroethene	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
2,4,6-Trinitrochlorobenzene	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
WATER QUALITY PARAMETERS (µg/L)																
Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Nitrite, Nitrate - non Specific	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Nitrogen By Kjeldahl Method	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Total Dissolved Solids	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Total Hardness	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Total Suspended Solids	NA	378000	NA	NA	NA	447000	NA	NA	NA	NA	NA	NA	NA	NA	NA	

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
PORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Field Sample Number: Field Sample Number:	ROUND 4		ROUND 3		ROUND 4		ROUND 3		ROUND 4		ROUND 3		ROUND 4	
	41M-93-03X 01/20/94 MX4103X2	41M-93-03X 01/20/94 MX4103X2	41M-93-04X 10/14/93 MX4104X1	41M-93-04X 10/14/93 MX4104X1	41M-93-04X 01/26/94 MX4104X2	41M-93-04X 01/26/94 MX4104X2	41M-93-03X 10/15/93 MX4103X1	41M-93-03X 10/15/93 MX4103X1	41M-93-03X 01/26/94 MX4103X2	41M-93-03X 01/26/94 MX4103X2	41M-93-03X 10/15/93 MX4103X1	41M-93-03X 10/15/93 MX4103X1	41M-93-03X 01/26/94 MX4103X2	41M-93-03X 01/26/94 MX4103X2
PAL CATIONS/ANIONS (µg/L)														
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL METALS (µg/L)														
Aluminum	6870	141	141	141	2670	141	141	141	141	141	141	141	141	141
Antimony	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Arsenic	10.5	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2
Barium	39.6	158	158	158	158	158	158	158	158	158	158	158	158	158
Beryllium	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Calcium	14700	15000	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310
Chromium	14.7	35.8	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02
Cobalt	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Copper	8.09	36	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Iron	9100	33500	136	136	136	136	136	136	136	136	136	136	136	136
Lead	4.25	22.9	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Manganese	3480	8340	1090	1090	1090	1090	1090	1090	1090	1090	1090	1090	1090	1090
Magnesium	291	1210	135	135	135	135	135	135	135	135	135	135	135	135
Mercury	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
Nickel	34.3	43.5	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Potassium	2370	8540	2760	2760	2760	2760	2760	2760	2760	2760	2760	2760	2760	2760
Silver	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Sodium	10800	7910	6840	6840	6840	6840	6840	6840	6840	6840	6840	6840	6840	6840
Vanadium	11	36.6	11	11	11	11	11	11	11	11	11	11	11	11
Zinc	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
PAL PESTICIDES (µg/L)														
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL EXPLOSIVES (µg/L)														
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL SEMI-VOLATILE ORGANICS (µg/L)														
*Bar (2-cylohexyl) Phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/L)														
1,2-dichloroethanes (on And Trans Isomers)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
xylene	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1,1,2,2-tetrachloroethane	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Carbon Disulfide	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Carbon Tetrachloride	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
*Chloroform	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
*Methylene Chloride	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Methyl Ethyl Ketone / 2-butanone	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Tetrachloroethane / Tetrachloroethene	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
*Toluene	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Benzene	150	150	150	150	150	150	150	150	150	150	150	150	150	150
2,4,6-Trichloroethene	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
WATER QUALITY PARAMETERS (µg/L)														
Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite - non Specific	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
Total Dissolved Solids	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness	2900000	2900000	2900000	2900000	2900000	2900000	2900000	2900000	2900000	2900000	2900000	2900000	2900000	2900000
Total Suspended Solids	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	ROUND 3		ROUND 6		ROUND 3		ROUND 6		ROUND 3	
	41M-92-01X 12/07/94 30 MX-4101X4	41M-92-01X 03/16/95 30 MX-4101X5	41M-92-01X 03/16/95 30 MX-4101X5	41M-92-01X 03/16/95 30 MX-4101X5	41M-93-02A 12/06/94 8 MX-4102A3	41M-93-02A 12/06/94 8 MX-4102A3	41M-93-02A 03/16/95 8 MX-4102A4	41M-93-02A 03/16/95 8 MX-4102A4	41M-93-02B 12/06/94 27 MX-4102B3	
PAL CATIONS/ANIONS (µg/L)										
Chloride	< 2120	NA	< 2120	NA	< 2120	NA	< 3510	NA	< 2120	
Phosphate	< 50000	NA	16000	NA	< 31.5	NA	< 305	NA	< 12000	
Sulfate	< 10000	NA	< 10000	NA	48000	NA	< 10000	NA	< 10000	
PAL METALS (µg/L)										
Aluminum	6870	171000	36400	< 141	2300	< 141	1270	< 141	160000	
Antimony	3.03	3.03	3.03	< 3.03	3.03	< 3.03	3.03	< 3.03	3.75	
Arsenic	10.5	48.5	35.3	< 2.54	2.54	< 2.54	2.54	< 2.54	68.7	
Barium	39.6	575	211	< 5	41.8	< 5	17.7	< 5	388	
Beryllium	5	5.72	5	< 5	5	< 5	5	< 5	5	
Calcium	14700	47500	18700	< 3310	9060	< 3310	5500	< 3310	34800	
Chromium	14.7	300	64.3	< 6.02	6.02	< 6.02	6.02	< 6.02	178	
Cobalt	25	126	39.6	< 25	25	< 25	25	< 25	91.4	
Copper	8.09	228	82.7	< 8.09	8.09	< 8.09	8.09	< 8.09	160	
Iron	9100	254000	43800	< 63.4	2930	< 63.4	1450	< 63.4	172000	
Lead	4.25	57.5	30	< 1.26	1.26	< 1.26	1.26	< 1.26	47.5	
Magnesium	3460	61600	13100	< 18.5	47.2	< 18.5	24.5	< 18.5	39400	
Manganese	291	3120	695	< 0.243	0.243	< 0.243	0.243	< 0.243	0.243	
Mercury	0.243	0.243	0.243	< 0.243	0.243	< 0.243	0.243	< 0.243	0.243	
Nickel	34.3	334	67.9	< 34.3	34.3	< 34.3	34.3	< 34.3	257	
Potassium	2370	37100	10700	< 967	3390	< 967	965	< 967	27100	
Silver	4.6	4.6	4.6	< 4.6	4.6	< 4.6	4.6	< 4.6	4.6	
Sodium	10800	12200	8930	< 6460	13300	< 6460	3040	< 6460	13600	
Vanadium	11	281	61.1	< 11	11	< 11	11	< 11	170	
Zinc	21.1	833	135	< 21.1	35.6	< 21.1	21.1	< 21.1	458	
PAL PESTICIDES (µg/L)										
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL EXPLOSIVES (µg/L)										
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PAL SEMI-VOLATILE ORGANICS (µg/L)										
*Bis (2-ethylhexyl) Phthalate	< 4.8	NA	< 4.8	NA	< 4.8	NA	< 4.8	NA	5.7 B	
PAL VOLATILE ORGANICS (µg/L)										
1,2-dichloroethane (cis And Trans Isomers)	< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	1.8	
Acetylene	< 0.84	NA	< 0.84	NA	< 0.84	NA	< 0.84	NA	0.91	
1,1,2,2-tetrachloroethane	< 34	NA	< 25	NA	< 0.51	NA	< 0.51	NA	1.9	
Carbon Disulfide	< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	0.5	
Carbon Tetrachloride	< 0.64	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	0.5	
*Chloroform	< 2.3	NA	< 2.2	NA	< 2.3	NA	< 2.3	NA	2.3	
*Methylene Chloride	< 6.4	NA	< 6.4	NA	< 6.4	NA	< 6.4	NA	6.4	
Methyl Ethyl Ketone / 2-butanone	< 2.2	NA	< 1.6	NA	< 1.6	NA	< 1.6	NA	1.6	
Tetrachloroethylene / Tetrachloroethane	< 6.4	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	2.1	
*Toluene	< 0.5	NA	< 0.5	NA	< 0.5	NA	< 0.5	NA	0.5	
Benzene	< 48	NA	< 24	NA	< 0.5	NA	< 0.5	NA	10	
Trichloroethylene / Trichloroethane	< 0.63	NA	< 0.63	NA	< 0.63	NA	< 0.63	NA	0.63	
2,4,6-Trinitrotoluene	< 0.63	NA	< 0.63	NA	< 0.63	NA	< 0.63	NA	0.63	
WATER QUALITY PARAMETERS (µg/L)										
Alkalinity	27000	NA	25000	NA	9000	NA	23000	NA	42000	
Nitrate, Nitrite-non Specific	58.4	NA	21.9	NA	< 10	NA	< 10	NA	16.4	
Nitrogen By Kjeldahl Method	305	NA	495	NA	714	NA	371	NA	419	
Total Dissolved Solids	118000	NA	60500	NA	34400	NA	19600	NA	66400	
Total Hardness	2700000	NA	1540000	NA	80000	NA	9750000	NA	11500000	
Total Suspended Solids										

TABLE 7-11

Site ID: Sample Date: Depth: Field Sample Number:	ROUND 3		ROUND 6		ROUND 5		ROUND 3		ROUND 6		ROUND 5	
	41M-93-02B 05/16/95 27 MX-4102B4	41M-93-02B 05/16/95 27 MX-4102B4	41M-93-02B 05/16/95 27 MX-4102B4	41M-93-02B 05/16/95 27 MX-4102B4	41M-94-02C 12/06/94 49.5 MX-4102C3	41M-94-02C 12/06/94 49.5 MX-4102C3	41M-94-02C 12/06/94 49.5 MX-4102C3	41M-94-02C 12/06/94 49.5 MX-4102C3	41M-94-02C 08/16/95 49.5 MX-4102C4	41M-94-02C 12/06/94 49.5 MX-4102C4	41M-93-03X 12/06/94 39 MX-4103X3	
PAL CATIONS/ANIONS (µg/L)												
Chloride												
Phosphate												
Sulfate												
PAL METALS (µg/L)												
Aluminum	6870	141	F	3100	563	F	141	F	141	F	1270	*
Antimony	3.03	3.03	F	3.03	3.03	F	3.03	F	3.03	F	3.03	3.39
Arsenic	10.5	4.26	F	6.4	7.04	F	2.54	F	2.54	F	5.33	3.62
Barium	39.6	5	F	93.5	5	F	5	F	5	F	8.32	5
Beryllium	5	5	F	5	5	F	5	F	5	F	5	5
Calcium	14700	4560	F	8100	3310	F	3470	F	3470	F	6200	4340
Chromium	14.7	6.02	F	15.8	6.02	F	6.02	F	6.02	F	10.3	6.02
Cobalt	25	25	F	25	25	F	25	F	25	F	25	25
Copper	8.09	8.09	F	22.9	8.09	F	8.09	F	8.09	F	34	8.09
Iron	9100	136	F	16200	94.3	F	38.8	F	38.8	F	1620	38.8
Lead	4.25	1.26	F	9.33	1.26	F	1.26	F	1.26	F	1.26	1.26
Magnesium	3480	2460	F	6080	703	F	749	F	749	F	2250	1990
Manganese	291	32.8	F	433	16.7	F	7.77	F	7.77	F	30.7	3.93
Mercury	0.243	0.243	F	0.243	0.243	F	0.243	F	0.243	F	0.243	0.243
Nickel	34.3	34.3	F	34.3	34.3	F	34.3	F	34.3	F	34.3	34.3
Potassium	2370	2350	F	5140	955	F	1440	F	1092	F	2690	1170
Silver	4.6	4.6	F	4.6	4.6	F	4.6	F	4.6	F	4.6	4.6
Sodium	10900	8700	F	9530	3160	F	3410	F	3400	F	6020	5410
Vanadium	11	11	F	21.3	11	F	11	F	11	F	37	11
Zinc	21.1	96	F	40.7	21.1	F	21.1	F	21.1	F	45.3	27.6
PAL PESTICIDES (µg/L)												
Endrin			NA			NA			NA		NA	NA
PAL EXPLOSIVES (µg/L)												
Nitroglycerin			NA			NA			NA		NA	NA
PAL SEMI-VOLATILE ORGANICS (µg/L)												
* Bis (2-ethylhexyl) Phthalate			NA			NA			NA		NA	NA
PAL VOLATILE ORGANICS (µg/L)												
1,2-dichloroethylenes (cis And Trans Isomers)			NA			NA			NA		4.8	NA
xylene			NA			NA			NA		1	NA
1,1,2,2-tetrachloroethane			NA			NA			NA		2	NA
Carbon Disulfide			NA			NA			NA		1	NA
Carbon Tetrachloride			NA			NA			NA		1	NA
* Chloroform			NA			NA			NA		1	NA
* Methylene Chloride			NA			NA			NA		1	NA
Methyl Ethyl Ketone / 2-butanone			NA			NA			NA		5	NA
Tetrachloroethylene / Tetrachloroethene			NA			NA			NA		10	NA
* Toluene			NA			NA			NA		3	NA
Benzene			NA			NA			NA		1	NA
TriChloroethylene / TriChloroethene			NA			NA			NA		1	NA
2,4,6-Trinitrochlorobenzene			NA			NA			NA		200	NA
WATER QUALITY PARAMETERS (µg/L)												
Alkalinity			NA			NA			NA		0.63	NA
Nitrite, Nitrate--non Specific			NA			NA			NA		2600	NA
Nitrogen By Kjeldahl Method			NA			NA			NA		1700	NA
Total Dissolved Solids			NA			NA			NA		183	NA
Total Hardness			NA			NA			NA		NA	NA
Total Suspended Solids			NA			NA			NA		26400	NA
			NA			NA			NA		449000	NA

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Field Sample Number: Field Sample Number:	ROUND 5		ROUND 6		ROUND 3		ROUND 6		ROUND 3		ROUND 6		ROUND 3	
	41M-93-03X 12/06/94 39 MD4103X3	41M-93-03X 12/06/94 39 MD4103X3	41M-93-03X 03/20/95 39 MX4103X4	41M-93-03X 03/20/95 39 MX4103X4	41M-93-03X 03/20/95 39 MX4103X4	41M-93-03X 03/20/95 39 MX4103X4	41M-94-03B 12/06/94 64 MX4103B3	41M-94-03B 12/06/94 64 MX4103B3	41M-94-03B 03/20/95 64 MX4103B4	41M-94-03B 03/20/95 64 MX4103B4	41M-94-03B 03/20/95 64 MX4103B4	41M-94-03B 03/20/95 64 MX4103B4	41M-94-03B 03/20/95 64 MX4103B4	41M-94-03B 03/20/95 64 MX4103B4
Port Devens Background Concentrations	2410 135 10000	NA NA NA	2520 104 10000	NA NA NA	NA NA NA	NA NA NA	2120 51.5 10000	NA NA NA	2740 3200 10000	NA NA NA	2740 3200 10000	NA NA NA	2740 3200 10000	NA NA NA
PAL CATIONS/ANIONS (µg/L)														
Chloride	6870	1360	1270	1270	1270	1270	141	141	141	141	141	141	141	141
Phosphate	3.03	3.03	DF	DF	DF	DF	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Sulfate	10.5	4.37	DF	DF	DF	DF	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
PAL METALS (µg/L)														
Aluminum	39.6	8.06	5	5	5	5	5	5	5	5	5	5	5	5
Antimony	14700	15000	8190	DF	DF	DF	5900	5900	5900	5900	5900	5900	5900	5900
Arsenic	14.7	35.8	6.02	DF	DF	DF	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02
Barium	25	25	DF	DF	DF	DF	25	25	25	25	25	25	25	25
Beryllium	8.09	57.9	DF	DF	DF	DF	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Bismuth	9100	22.9	DF	DF	DF	DF	1980	1980	1980	1980	1980	1980	1980	1980
Boron	4.25	1.26	DF	DF	DF	DF	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Calcium	3480	2430	1960	DF	DF	DF	1960	1960	1960	1960	1960	1960	1960	1960
Chromium	291	31.0	DF	DF	DF	DF	3.63	3.63	3.63	3.63	3.63	3.63	3.63	3.63
Copper	0.243	0.243	DF	DF	DF	DF	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
Iron	34.3	48.5	DF	DF	DF	DF	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Lead	2370	8340	DF	DF	DF	DF	1940	1940	1940	1940	1940	1940	1940	1940
Magnesium	4.6	4.6	DF	DF	DF	DF	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Manganese	10000	7910	DF	DF	DF	DF	5740	5740	5740	5740	5740	5740	5740	5740
Mercury	11	36.6	DF	DF	DF	DF	11	11	11	11	11	11	11	11
Nickel	21.1	146	DF	DF	DF	DF	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL PESTICIDES (µg/L)														
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL EXPLOSIVES (µg/L)														
Trinitrobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL SEMI-VOLATILE ORGANICS (µg/L)														
Bis (2-ethylhexyl) Phthalate	10	B	12	12	12	12	NA	NA	NA	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/L)														
1,2-dichloroethene (cis And Trans Isomers)	0.5	0.5	1	1	1	1	NA	NA	NA	NA	NA	NA	NA	NA
1,1,2,2-tetrachloroethane	0.84	0.84	2	2	2	2	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Disulfide	0.51	0.51	1	1	1	1	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	0.5	0.5	0.5	0.5	0.5	0.5	NA	NA	NA	NA	NA	NA	NA	NA
*Chloroform	0.5	0.5	1	1	1	1	NA	NA	NA	NA	NA	NA	NA	NA
*Methylene Chloride	2.3	2.3	5	5	5	5	NA	NA	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone / 2-butanone	6.4	6.4	10	10	10	10	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethylene / Tetrachloroethene	1	1	3	3	3	3	NA	NA	NA	NA	NA	NA	NA	NA
*Toluene	0.5	0.5	0.5	0.5	0.5	0.5	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	200	200	180	180	180	180	NA	NA	NA	NA	NA	NA	NA	NA
2,4,6-Trinitrobenzene	0.63	0.63	0.63	0.63	0.63	0.63	NA	NA	NA	NA	NA	NA	NA	NA
WATER QUALITY PARAMETERS (µg/L)														
Alkalinity	NA	NA	26000	26000	26000	26000	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate - non Specific	NA	NA	1700	1700	1700	1700	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method	NA	NA	183	183	183	183	NA	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids	64000	64000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness	NA	NA	26400	26400	26400	26400	NA	NA	NA	NA	NA	NA	NA	NA
Total Suspended Solids	280000	280000	135000	135000	135000	135000	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

	ROUND 3		ROUND 6		ROUND 3		ROUND 6	
	41M-93-04X 12/07/94 6.5 MX4104X3	41M-93-04X 05/14/95 6.5 MX4104X4	41M-93-04X 05/14/95 6.5 MX4104X4	41M-93-04X 05/14/95 6.5 MD4104X4	41M-93-05X 12/07/94 6.5 MX4105X3	41M-93-05X 05/14/95 6.5 MX4105X4	41M-93-05X 05/14/95 6.5 MX4105X4	41M-93-05X 03/14/95 6.5 MX4105X4
Site ID: Sample Date: Depth: Field Sample Number: Field Sample Number: (µg/L)	Port Devens Background Concentrations							
PAL CATIONS/ANIONS (µg/L)								
Chloride	NA	2740	NA	2850	NA	2630	NA	NA
Phosphate	NA	381	NA	13.3	NA	13.3	21	NA
Sulfate	NA	10000	NA	10000	NA	10000	10000	NA
PAL METALS (µg/L)								
Aluminum	141	2870	141	141	DF	12900	141	141
Antimony	3.03	3.03	3.03	3.03	DF	3.03	3.03	3.03
Arsenic	10.5	20.1	10.5	13.6	DF	3.03	3.03	3.03
Barium	39.6	20.8	10.5	4.97	DF	7.04	2.54	12.7
Beryllium	5	5	5	5	DF	39.4	83.4	5
Calcium	14700	2510	2440	2000	DF	5	5	5
Chromium	14.7	6.12	6.02	6.02	DF	3840	3510	2530
Cobalt	25	25	25	25	DF	14.4	31.7	6.02
Copper	8.09	8.09	8.09	8.09	DF	25	25	25
Iron	9100	6390	1090	4160	DF	11.9	23.9	8.09
Lead	4.25	3.47	1.26	1.26	DF	23500	1.26	1.26
Magnesium	3480	500	500	500	DF	1.26	1.26	1.26
Manganese	291	86.1	68	112	DF	3140	5230	611
Mercury	0.243	0.243	0.243	0.243	DF	335	482	173
Nickel	34.3	34.3	34.3	34.3	DF	34.3	34.3	0.243
Potassium	2370	1660	1190	1620	DF	3850	34.3	34.3
Silver	4.6	4.6	4.6	4.6	DF	4.6	4.6	4.6
Sodium	10800	1790	1610	1640	DF	1750	1830	1720
Vanadium	11	11	11	11	DF	2380	2320	11
Zinc	21.1	42.5	36.4	21.1	DF	34.3	21.1	25.4
PAL PESTICIDES (µg/L)								
Endrin	NA	NA	NA	NA	NA	NA	NA	NA
PAL EXPLOSIVES (µg/L)								
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA
PAL SEMI-VOLATILE ORGANICS (µg/L)								
Bis (2-ethylhexyl) Phthalate	NA	4.5	NA	4.8	NA	6.3	15	NA
PAL VOLATILE ORGANICS (µg/L)								
1,2-dichloroethene (cis And Trans Isomers)	NA	0.5	NA	0.5	NA	0.5	0.5	NA
1,1,2,2-tetrachloroethane	NA	0.51	NA	0.51	NA	0.51	0.51	NA
Carbon Disulfide	NA	0.5	NA	0.5	NA	0.5	0.5	NA
Carbon Tetrachloride	NA	0.5	NA	0.5	NA	0.5	0.5	NA
*Chloroform	NA	0.5	NA	0.5	NA	0.5	0.5	NA
*Methylene Chloride	NA	2.3	NA	2.3	NA	2.3	2.3	NA
Methyl Ethyl Ketone / 2-butanone	NA	6.4	NA	6.4	NA	6.4	6.4	NA
Tetrachloroethene / Tetrachloroethane	NA	1.6	NA	1.6	NA	1.6	1.6	NA
*Toluene	NA	0.5	NA	0.5	NA	0.5	0.5	NA
Benzene	NA	0.5	NA	0.5	NA	0.5	0.5	NA
Trichloroethene / Trichloroethane	NA	0.5	NA	0.5	NA	0.5	0.5	NA
2,4,6-Trinitrotoluene	NA	0.63	NA	0.63	NA	0.63	0.63	NA
WATER QUALITY PARAMETERS (µg/L)								
Alkalinity	NA	7000	NA	11000	NA	10000	NA	NA
Nitrate, Nitrate-nitrogen	NA	10	NA	10	NA	21.3	NA	NA
Nitrogen By Kjeldahl Method	NA	590	NA	476	NA	181	NA	NA
Total Dissolved Solids	NA	NA	NA	NA	NA	NA	25000	NA
Total Hardness	NA	17600	NA	18600	NA	9.2	NA	NA
Total Suspended Solids	NA	27000	NA	18000	NA	350000	70000	NA

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Sample Number: Field Sample Number: Concentration	ROUND 3		ROUND 4		ROUND 5		ROUND 6		ROUND 7		ROUND 8		ROUND 9	
	41M-94-06X 12/07/94 14.3 MX4106X3	41M-94-06X 12/07/94 14.3 MX4106X3	41M-94-06X 09/13/95 14.3 MX4106X4	41M-94-06X 09/13/95 14.3 MX4106X4	41M-94-07X 12/07/94 8 MX4107X3	41M-94-07X 12/07/94 8 MX4107X3	41M-94-07X 09/13/95 8 MX4107X4	41M-94-07X 09/13/95 8 MX4107X4	41M-94-07X 09/13/95 8 MX4107X4	41M-94-07X 09/13/95 8 MX4107X4	41M-94-07X 09/13/95 8 MX4107X4	41M-94-07X 09/13/95 8 MX4107X4	41M-94-07X 09/13/95 8 MX4107X4	41M-94-07X 09/13/95 8 MX4107X4
Fort Devens Background Concentration	2520	13.3	NA	NA	2630	560	NA	NA	2740	13.3	NA	NA	2120	NA
Chloride	<	10000	<	10000	<	10000	<	10000	<	10000	<	10000	<	10000
Sulfate	<	10000	<	10000	<	10000	<	10000	<	10000	<	10000	<	10000
PAL METALS (µg/L)														
Aluminum	6870	141	141	141	141	357	141	141	141	141	141	141	141	141
Antimony	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Arsenic	10.5	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
Barium	39.6	5	5	5	5	5	5	5	5	5	5	5	5	5
Beryllium	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Calcium	14700	2370	2820	2190	2090	2350	2090	2350	2090	2350	2090	2350	2090	2350
Chromium	14.7	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02
Cobalt	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Copper	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Iron	9100	38.8	38.8	146	38.8	292	38.8	292	38.8	292	38.8	292	38.8	292
Lead	4.25	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Magnesium	3480	500	500	500	500	500	500	500	500	500	500	500	500	500
Manganese	291	10.7	13	10	6.54	18.2	6.54	18.2	6.54	18.2	6.54	18.2	6.54	18.2
Mercury	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
Nickel	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Potassium	2370	661	493	375	671	375	671	375	671	375	671	375	671	375
Silver	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Sodium	10800	1960	2200	1590	1540	2740	1540	2740	1540	2740	1540	2740	1540	2740
Vanadium	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Zinc	21.1	21.1	54.8	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
PAL PESTICIDES (µg/L)														
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL EXPLOSIVES (µg/L)														
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL SEMI-VOLATILE ORGANICS (µg/L)														
Bis (2-ethylhexyl) Phthalate	9.1	NA	NA	4.4	NA	49	NA	NA	NA	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/L)														
1,2-dichloroethene (cis And Trans Isomers)	<	0.5	NA	<	0.5	<	0.5	NA	<	0.5	NA	<	0.5	NA
xylenes	<	0.84	NA	<	0.84	NA	<	0.84	NA	<	0.84	NA	<	0.84
1,1,2,2-tetrachloroethane	<	0.51	NA	<	0.51	NA	<	0.51	NA	<	0.51	NA	<	0.51
Carbon Disulfide	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5
Carbon Tetrachloride	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5
*Chloroform	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5
*Methylene Chloride	<	2.3	NA	<	2.3	NA	<	2.3	NA	<	2.3	NA	<	2.3
Methyl Ethyl Ketone / 2-butanone	<	6.4	NA	<	6.4	NA	<	6.4	NA	<	6.4	NA	<	6.4
Tetrachloroethene / Tetrachloroethane	<	1.6	NA	<	1.6	NA	<	1.6	NA	<	1.6	NA	<	1.6
*Toluene	<	0.74	NA	<	0.74	NA	<	0.74	NA	<	0.74	NA	<	0.74
Benzene	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5
Trichloroethene / Trichloroethane	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5	NA	<	0.5
2,4,6-Trinitrophenol	<	0.63	NA	<	0.63	NA	<	0.63	NA	<	0.63	NA	<	0.63
WATER QUALITY PARAMETERS (µg/L)														
Alkalinity	7000	NA	NA	<	5000	NA	NA	<	5000	NA	NA	<	5000	NA
Nitrate - non Specific	<	20.6	NA	<	10	NA	NA	<	10	NA	NA	<	10	NA
Nitrogen By Kjeldahl Method	<	183	NA	<	183	NA	NA	<	183	NA	NA	<	183	NA
Total Dissolved Solids	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Hardness	<	6.8	NA	6900	NA	NA	NA	6	NA	NA	NA	7200	NA	NA
Total Suspended Solids	<	4000	NA	345000	NA	8000	NA	184000	NA	NA	NA	184000	NA	NA

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
PORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: PAL CATIONS/ANIONS (µg/L)	ROUND 3		ROUND 4		ROUND 5		ROUND 6		ROUND 7		ROUND 8		ROUND 9		ROUND 10	
	41M-94-08A 12/07/94 76.9 MX-4108A3	41M-94-08A 03/15/95 26.9 MX-4108A4	41M-94-08B 12/08/94 42 MX-4108B3	41M-94-08B 03/16/95 42 MX-4108B4	41M-94-08B 12/08/94 42 MX-4108B3	41M-94-08B 03/16/95 42 MX-4108B4	41M-94-08B 12/08/94 42 MX-4108B3	41M-94-08B 03/16/95 42 MX-4108B4	41M-94-08B 12/08/94 42 MX-4108B3	41M-94-08B 03/16/95 42 MX-4108B4	41M-94-08B 12/08/94 42 MX-4108B3	41M-94-08B 03/16/95 42 MX-4108B4	41M-94-08B 12/08/94 42 MX-4108B3	41M-94-08B 03/16/95 42 MX-4108B4	41M-94-08B 12/08/94 42 MX-4108B3	41M-94-08B 03/16/95 42 MX-4108B4
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL METALS (µg/L)																
Aluminum	6870	1330	1510	731	141	731	141	731	141	731	141	731	141	731	141	731
Antimony	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Arsenic	10.5	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
Barium	39.6	8.73	17.9	10.4	5	5	5	5	5	5	5	5	5	5	5	5
Beryllium	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Calcium	14700	8690	8720	8690	8690	8690	8690	8690	8690	8690	8690	8690	8690	8690	8690	8690
Chromium	14.7	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02
Cobalt	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Copper	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Iron	9100	38.8	126	126	126	126	126	126	126	126	126	126	126	126	126	126
Lead	4.25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Magnesium	3460	2520	2910	2510	2510	2510	2510	2510	2510	2510	2510	2510	2510	2510	2510	2510
Manganese	291	488	385	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8
Mercury	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
Nickel	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Potassium	2370	3460	3460	3460	3460	3460	3460	3460	3460	3460	3460	3460	3460	3460	3460	3460
Silver	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Sodium	10000	7610	7610	7610	7610	7610	7610	7610	7610	7610	7610	7610	7610	7610	7610	7610
Vanadium	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Zinc	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
PAL PESTICIDES (µg/L)																
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL EXPLOSIVES (µg/L)																
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL SEMIVOLATILE ORGANICS (µg/L)																
*Bis (2-ethylhexyl) Phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/L)																
1,2-dichloroethane (cis And Trans Isomers)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,1,2,2-tetrachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Disulfide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
*Chloroform	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
*Methylene Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl Ethyl Ketone / 2-butanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethylene / Tetrachloroethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
*Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethylene / Trichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4,6-Trinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
WATER QUALITY PARAMETERS (µg/L)																
Alkalinity	NA	46000	46000	46000	46000	46000	46000	46000	46000	46000	46000	46000	46000	46000	46000	46000
Nitrate, Nitrite - non Specific	NA	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Nitrogen By Kjeldahl Method	NA	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183
Total Dissolved Solids	NA	34400	34400	34400	34400	34400	34400	34400	34400	34400	34400	34400	34400	34400	34400	34400
Total Hardness	NA	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000
Total Suspended Solids	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC-41 UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIATION INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Concentrations	ROUND 5		ROUND 6		ROUND 5		ROUND 6		ROUND 5		ROUND 6		ROUND 5	
	41M-94-09B 12/05/94 58 MX4109B3	41M-94-09B 03/17/95 58 MX4109B4	41M-94-09B 03/17/95 58 MX4109B4	41M-94-09B 03/17/95 58 MX4109B4	41M-94-10X 12/06/94 37.5 MX4110X3	41M-94-10X 03/17/95 37.5 MX4110X4	41M-94-10X 03/17/95 37.5 MX4110X4	41M-94-10X 03/17/95 37.5 MX4110X4	41M-94-11X 12/06/94 49.5 MX4111X3	41M-94-11X 12/06/94 49.5 MX4111X3	41M-94-11X 12/06/94 49.5 MX4111X3	41M-94-11X 12/06/94 49.5 MX4111X3	41M-94-11X 12/06/94 49.5 MX4111X3	41M-94-11X 12/06/94 49.5 MX4111X3
PAL CATIONS/ANIONS (µg/L)														
Chloride	2740	NA	2850	NA	2520	NA	2520	NA	2120	NA	2120	NA	2120	NA
Phosphate	249	NA	103	NA	15000	NA	15000	NA	2500	NA	2500	NA	2500	NA
Sulfate	10000	NA	10000	NA	45000	NA	45000	NA	10000	NA	10000	NA	10000	NA
PAL METALS (µg/L)														
Aluminum	6870	203	141	NA	96300	NA	96300	NA	2910	NA	2910	NA	3040	NA
Antimony	3.03	3.03	3.03	NA	3.66	NA	3.66	NA	3.03	NA	3.03	NA	3.03	NA
Arsenic	10.5	3.62	2.54	NA	59.8	NA	59.8	NA	3.84	NA	3.84	NA	3.84	NA
Barium	39.6	6.4	5.56	NA	337	NA	337	NA	21.7	NA	21.7	NA	24	NA
Beryllium	5	5	5	NA	5	NA	5	NA	5	NA	5	NA	5	NA
Calcium	14700	3650	3840	NA	49300	NA	49300	NA	7710	NA	7710	NA	7040	NA
Chromium	14.7	6.02	6.02	NA	155	NA	155	NA	6.02	NA	6.02	NA	6.02	NA
Cobalt	25	25	25	NA	66.7	NA	66.7	NA	25	NA	25	NA	25	NA
Copper	8.09	8.09	8.09	NA	113	NA	113	NA	8.09	NA	8.09	NA	8.09	NA
Iron	9100	108	38.8	NA	144000	NA	144000	NA	3090	NA	3090	NA	43	NA
Lead	4.25	1.26	1.26	NA	46.6	NA	46.6	NA	2.17	NA	2.17	NA	2.06	NA
Magnesium	3480	500	500	NA	40600	NA	40600	NA	1.26	NA	1.26	NA	4780	NA
Manganese	291	33.3	21.8	NA	2670	NA	2670	NA	4010	NA	4010	NA	286	NA
Mercury	0.243	0.243	0.243	NA	0.243	NA	0.243	NA	0.243	NA	0.243	NA	0.243	NA
Nickel	34.3	34.3	34.3	NA	173	NA	173	NA	34.3	NA	34.3	NA	34.3	NA
Potassium	2370	1750	520	NA	25900	NA	25900	NA	7910	NA	7910	NA	3790	NA
Silver	4.6	4.6	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA
Sodium	10800	3830	2740	NA	19800	NA	19800	NA	18100	NA	18100	NA	5500	NA
Vanadium	11	11	11	NA	153	NA	153	NA	11	NA	11	NA	11	NA
Zinc	21.1	21.1	21.1	NA	375	NA	375	NA	21.1	NA	21.1	NA	48.3	NA
PAL PESTICIDES/PCBS (µg/L)														
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL EXPLOSIVES (µg/L)														
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL SEMI-VOLATILE ORGANICS (µg/L)														
1,2-dichloroethylenes (cis And Trans Isomers)	4.8	23	8.7	NA	8.7	NA	8.7	NA	5.4	NA	5.4	NA	18	NA
PAL VOLATILE ORGANICS (µg/L)														
xylenes	0.5	0.5	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA
1,1,2,2-tetrachloroethane	0.84	0.84	0.84	NA	0.84	NA	0.84	NA	0.84	NA	0.84	NA	0.84	NA
Carbon Disulfide	0.51	0.51	0.51	NA	0.51	NA	0.51	NA	0.51	NA	0.51	NA	0.51	NA
Carbon Tetrachloride	0.5	0.5	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA
*Chloroform	58	58	58	NA	58	NA	58	NA	58	NA	58	NA	58	NA
*Methylene Chloride	5	5	5	NA	5	NA	5	NA	5	NA	5	NA	5	NA
Methyl Ethyl Ketone / 2-butanone	2.3	2.3	2.3	NA	2.3	NA	2.3	NA	2.3	NA	2.3	NA	2.3	NA
Tetrachloroethylene / Tetrachloroethene	6.4	6.4	6.4	NA	6.4	NA	6.4	NA	6.4	NA	6.4	NA	6.4	NA
*Toluene	1.6	1.6	1.6	NA	1.6	NA	1.6	NA	1.6	NA	1.6	NA	1.6	NA
Benzene	0.65	0.65	0.65	NA	0.65	NA	0.65	NA	0.65	NA	0.65	NA	0.65	NA
Trichloroethylene / Trichloroethene	0.5	0.5	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA
2,4,6-Trinitrotoluene	0.63	0.63	0.63	NA	0.63	NA	0.63	NA	0.63	NA	0.63	NA	0.63	NA
PAL WATER QUALITY PARAMETERS (µg/L)														
alkalinity	14000	11000	53000	NA	53000	NA	53000	NA	43000	NA	43000	NA	31000	NA
nitrite, Nitrate - non Specific	400	550	10	NA	10	NA	10	NA	10	NA	10	NA	10	NA
nitrogen By Kjeldahl Method	183	183	362	NA	362	NA	362	NA	324	NA	324	NA	183	NA
total Dissolved Solids	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
total Hardness	12400	10800	16000	NA	16000	NA	16000	NA	31600	NA	31600	NA	18.8	NA
total Suspended Solids	4000	9000	11300000	NA	11300000	NA	11300000	NA	351000	NA	351000	NA	41000	NA

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC-41 UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIATION INVESTIGATION REPORT
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Concentrations	ROUND 6		ROUND 5		ROUND 6		ROUND 5		ROUND 6	
	41M-94-11X 03/14/95 49.5 MX4111X4	41M-94-11X 03/14/95 49.5 MX4111X4	41M-94-12X 12/08/94 38 MX4112X3	41M-94-12X 12/08/94 38 MX4112X3	41M-94-12X 03/15/95 38 MX4112X4	41M-94-12X 03/15/95 38 MX4112X4	41M-94-13X 12/08/94 28.5 MX4113X3	41M-94-13X 12/08/94 28.5 MX4113X3	41M-94-13X 03/16/95 28.5 MX4113X4	41M-94-13X 03/16/95 28.5 MX4113X4
Chloride	2120	NA	2120	NA	2120	NA	2120	NA	2120	NA
Phosphate	106	NA	443	NA	247	NA	37.3	NA	135	NA
Sulfate	1000	NA	1600	NA	1000	NA	1000	NA	1000	NA
PAL METALS (µg/L)										
Aluminum	6870	141	16100	141	10000	141	961	141	5300	141
Antimony	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Arsenic	10.5	7.68	19.4	6.08	11.2	2.54	2.54	2.54	6.4	2.54
Barium	39.6	5	86.6	7.13	58.7	8.89	9.35	5	26.5	5
Beryllium	5	5	5	5	5	5	5	5	5	5
Calcium	14700	8000	16600	11800	9110	6740	8510	7460	7060	5600
Chromium	14.7	6.02	25.2	6.02	19.2	6.02	6.02	6.02	7.74	6.02
Cobalt	25	25	25	25	25	25	25	25	25	25
Copper	8.09	8.09	16.3	10.9	14.7	8.09	8.09	8.09	8.09	8.09
Iron	9100	1140	21600	125	13900	75.5	1200	38.8	6220	38.8
Lead	4.25	1.26	8.13	1.26	7.16	1.26	1.26	1.26	4.01	1.26
Magnesium	3480	1840	8990	2740	6570	2650	1550	1100	2550	1280
Manganese	291	19.4	514	64.5	402	216	54.7	32.2	774	120
Mercury	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
Nickel	34.3	34.3	13100	8300	34.3	34.3	34.3	34.3	34.3	34.3
Potassium	2370	3140	2690	8300	6990	3350	2170	1730	2280	913
Silver	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Sodium	10800	5640	14700	11800	12500	11000	7210	6780	7460	6790
Vanadium	11	11	38.4	11	17.7	11	11	11	11	11
Zinc	21.1	21.1	59.5	21.1	39.4	21.1	21.1	21.1	21.1	21.1
PAL PESTICIDES/PCBS (µg/L)										
Endrin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL EXPLOSIVES (µg/L)										
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL SEMIVOLATILE ORGANICS (µg/L)										
*Bis (2-ethylhexyl) Phthalate	10	NA	59	NA	7.4	NA	4.8	NA	4.8	NA
PAL VOLATILE ORGANICS (µg/L)										
1,2-dichloroethylenes (cis And Trans Isomers)	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA
xylene	0.84	NA	0.84	NA	0.84	NA	0.84	NA	0.84	NA
1,1,2,2-tetrachloroethane	0.51	NA	0.51	NA	0.51	NA	0.51	NA	0.51	NA
Carbon Disulfide	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA
Carbon Tetrachloride	58	NA	58	NA	58	NA	58	NA	58	NA
*Chloroform	5	NA	5	NA	5	NA	5	NA	5	NA
*Methylene Chloride	2.3	NA	2.3	NA	2.3	NA	2.3	NA	2.3	NA
Methyl Ethyl Ketone / 2-butanone	6.4	NA	6.4	NA	6.4	NA	6.4	NA	6.4	NA
Tetrachloroethylene / Tetrachloroethene	1.6	NA	1.6	NA	1.6	NA	1.6	NA	1.6	NA
Benzene	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA
*Toluene	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA
Trichloroethylene / Trichloroethene	0.63	NA	0.63	NA	0.63	NA	0.63	NA	0.63	NA
2,4,6-Trinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAL WATER QUALITY PARAMETERS (µg/L)										
alkalinity	3200	NA	6100	NA	4300	NA	3300	NA	2500	NA
nitrite, Nitrate - non Specific	10	NA	10	NA	10	NA	10	NA	10	NA
nitrogen By Kjeldahl Method	419	NA	276	NA	305	NA	183	NA	333	NA
total Dissolved Solids	27000	NA	50400	NA	35600	NA	24000	NA	22800	NA
total Hardness	56000	NA	87500	NA	36000	NA	169000	NA	198000	NA

TABLE 7-11
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS
AOC-41 UNAUTHORIZED DUMPING AREA (SITE A)
REMEDIAL INVESTIGATION REPORT
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Site ID: Sample Date: Depth: Field Sample Number: Concentrations	ROUND 5				ROUND 6			
	41M-94-14X 12/07/94 8 MX4114X3	41M-94-14X 12/07/94 8 MD4114X3	41M-94-14X 12/07/94 8 MX4114X3	41M-94-14X 12/07/94 8 MD4114X3	41M-94-14X 03/13/95 8 MX4114X4	41M-94-14X 03/13/95 8 MX4114X4	41M-94-14X 03/13/95 8 MX4114X4	41M-94-14X 03/13/95 8 MX4114X4
FAL CATIONS/ANIONS (µg/L)								
Chloride	2740	2740	D	NA	NA	2120	?	NA
Phosphate	13.3	13.3	D	NA	NA	990	?	NA
Sulfate	10000	10000	D	NA	NA	10000	?	NA
FAL METALS (µg/L)								
Aluminum	6870	141	D	141	F	141	F	141
Antimony	3.03	3.03	D	3.03	F	3.03	DF	3.03
Arsenic	10.5	2.54	D	2.54	F	2.54	DF	2.54
Barium	39.6	5.76	D	5	F	5	DF	5
Beryllium	5	5	D	5	F	5	DF	5
Calcium	14700	3320	D	3420	F	3390	DF	3220
Chromium	14.7	6.02	D	6.02	F	6.02	DF	6.02
Cobalt	25	25	F	25	F	25	DF	25
Copper	8.09	8.09	D	8.09	F	8.09	DF	8.09
Iron	9100	38.8	D	131	F	81.7	DF	38.8
Lead	4.25	1.26	D	1.26	F	1.26	DF	1.26
Magnesium	3480	500	D	500	F	500	DF	500
Manganese	291	55.6	D	101	F	52.5	DF	4.74
Mercury	0.243	0.243	D	0.243	F	0.243	DF	0.243
Nickel	34.3	34.3	D	34.3	F	34.3	DF	34.3
Potassium	2370	726	D	1150	F	715	DF	375
Silver	4.6	4.6	D	4.6	F	4.6	DF	4.6
Sodium	10800	2050	D	2130	F	2110	DF	2270
Vanadium	11	11	D	11	F	11	DF	11
Zinc	21.1	21.1	D	21.1	F	21.1	DF	21.1
FAL PESTICIDES/PCBS (µg/L)								
Endrin	NA	NA	NA	NA	NA	NA	NA	NA
FAL EXPLOSIVES (µg/L)								
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA
FAL SEMI-VOLATILE ORGANICS (µg/L)								
*Bis (2-ethylhexyl) Phthalate	4.8	20	D	NA	NA	4.8	NA	NA
FAL VOLATILE ORGANICS (µg/L)								
1,2-dichloroethylenes (cis And Trans Isomers)	0.5	0.5	D	NA	NA	0.5	NA	NA
Xylenes	0.84	0.84	D	NA	NA	0.84	NA	NA
1,1,2,2-tetrachloroethane	0.51	0.51	D	NA	NA	0.51	NA	NA
Carbon Disulfide	0.5	0.5	D	NA	NA	0.5	NA	NA
Carbon Tetrachloride	0.58	0.58	D	NA	NA	0.58	NA	NA
*Chloroform	0.68	0.68	D	NA	NA	0.68	NA	NA
*Methylene Chloride	2.3	2.3	D	NA	NA	2.3	NA	NA
Methyl Ethyl Ketone / 2-butanone	6.4	6.4	D	NA	NA	6.4	NA	NA
Tetrachloroethylene / Tetrachloroethene	1.6	1.6	D	NA	NA	1.6	NA	NA
*Toluene	0.5	0.5	D	NA	NA	0.5	NA	NA
Benzene	0.5	0.5	D	NA	NA	0.5	NA	NA
Trichloroethylene / Trichloroethene	1.2	1.2	D	NA	NA	1.2	NA	NA
2,4,6-Trinitrochlorobenzene	0.63	0.63	D	NA	NA	0.63	NA	NA
FAL WATER QUALITY PARAMETERS (µg/L)								
alkalinity	10000	9000	D	NA	NA	8000	NA	NA
nitrite, Nitrate-non Specific	12	11.9	D	NA	NA	10	NA	NA
nitrogen By Kjeldahl Method	183	183	D	NA	NA	1430	NA	NA
total Dissolved Solids	NA	NA	D	NA	NA	NA	NA	NA
total Hardness	8.8	8.8	D	NA	NA	11600	NA	NA
total Suspended Solids	4000	4000	D	NA	NA	528000	NA	NA

8.0 CONTAMINANT FATE AND TRANSPORT

This section discusses the migration potential and probable environmental fate of general compound and analyte groups identified at the AOC 41. Suspected site-related contaminants are limited to VOCs mentioned in Section 7.0. The observed distribution of these analytes in groundwater is the result of their physical and chemical properties and the physical driving forces and resistances present at the site. For organic chemicals, these physical and chemical properties include density, solubility, volatility, and organic carbon partition coefficient (K_{oc}). Site-specific conditions governing fate and transport (i.e., persistence and migration) of analytes include concentration, topography, meteorological conditions, geologic setting, and in the case of groundwater, hydrogeology. A conceptual model of the site is also presented.

8.1 COMPOUND PROPERTIES AND TRANSPORT PROCESSES

The site-related contaminant compounds detected at AOC 41 are limited to chlorinated solvents (TCE; PCE; 1,1,2,2-TCA; and cis-1,2-DCE). The chlorinated solvents in groundwater appear to be a result of uncontrolled disposal/spills of an undetermined amount of a solvent-based liquid. Relatively low concentrations of SVOCs such as acenaphthalene, anthracene, benzo(a)pyrene, chrysene, and phenanthrene were detected in soil samples collected from two test pits at AOC 41.

The persistence of compounds in soil is determined by chemical properties, source configurations and releases, geochemical and biochemical reactions, and soil and meteorological conditions. Factors and processes that control the persistence of chemicals in water-bearing units, in addition to the aforementioned factors, are water-bearing unit characteristics, advection, and hydrodynamic dispersion. Compounds may exist in the surface and subsurface in gaseous, aqueous, or solid phases. The fate of these compounds is controlled by a combination of all of these factors.

The following subsections discuss general physical and chemical properties, and how these properties affect transport and general attenuation processes.

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8.1.1 Physical and Chemical Properties Significant to Fate and Transport

This subsection discusses the physical and chemical properties which affect the fate and transport of contaminants in the environment. Physical and chemical properties of organic contaminants of concern detected at AOC 41 are presented in Table 8-1. Table 8-2 summarizes the relative mobilities of selected inorganic elements in different chemical environments.

Many values for physical and chemical properties of TCL analytes are listed in "Basics of Pump-and-Treat Groundwater Remediation Technology" (USEPA, 1990) including specific gravities, K_{oc} , solubility, and volatility. This reference document does not include inorganics, because analyses conducted measure the total amount of a particular constituent in the sample rather than the actual chemical form or metal's oxidation state. The distribution of specific solute species, pH, and oxidation are important factors in establishing the total solubility or mobility of a given inorganic element.

Specific gravity is the ratio of the mass of a given volume of a liquid substance to the mass of an equal volume of water. Liquids with specific gravities greater than 1 are termed "heavier" than water.

Solubility measures the partitioning between the aqueous phase and solid form of a chemical, and the tendency of a material to dissolve in water. Substances with lower solubilities are more likely to remain in a separate phase when in contact with water; substances with higher solubilities will dissolve into, and move with, water.

Volatility measures the tendency of a chemical to partition into the gaseous phase. Volatility can be predicted by an analyte's vapor pressure and Henry's Law Constant value (H). Volatility of a compound increases with increasing vapor pressure. Compounds with H values less than 1.0×10^{-5} have a low degree of volatility, and those with H values below 3.0×10^{-7} are considered non-volatile. H values between 1.0×10^{-5} and 1.0×10^{-3} (e.g., anthracene, naphthalene, PCBs) are moderately volatile, while those with values exceeding 1.0×10^{-3} (e.g., TCE and cis-1,2-DCE) are considered highly volatile.

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K_{oc} measures the extent that an organic chemical partitions between organic carbon and a liquid phase, and is used to predict to what extent a chemical could be adsorbed to soil organic carbon. Chemicals with a K_{oc} greater than 10,000 (e.g., anthracene, chrysene, and phenanthrene) will tend to adsorb strongly to soil organic carbon. Chemicals with a K_{oc} ranging from 1,000 to 10,000 will moderately adsorb, and move slowly in the soil profile. Chemicals with a K_{oc} of less than 1,000 weakly adsorb to soil organic carbon and tend to be more mobile. Examples of weakly adsorbed compounds include many VOCs, such as cis-1,2-DCE.

8.1.2 General Transport and Attenuation Processes

Migration and persistence are controlled by various transport and attenuation processes. Processes that tend to disperse contaminants include surface water and groundwater movement (including the movement of dissolved and suspended contaminants), facilitated transport, leaching by dissolution or desorption, and surface erosion.

The solubility of a compound in water is considered to be the most important transport factor, because it determines the maximum concentration dissolved in water. Knowledge of the solubility of a chemical provides considerable insight into the potential fate and transport of that chemical. In general, highly soluble compounds are less likely to partition into soil or sediment, or to volatilize from water, and are more likely to biodegrade (Montgomery, 1991).

Dissolved phase transport can occur via two processes: advection or dispersion. Advection involves transport with flowing groundwater and migrating with the mean velocity of the solvent (groundwater plus dissolved compounds). When compounds move through the ground by advection, they are subject to spreading within the ground through variable conductive pathways, which allows compounds with little or no affinity for soils to migrate faster than the average groundwater velocity. This spreading is known as dispersion. Hydrodynamic dispersion has two components: molecular diffusion and mechanical dispersion (USEPA, 1989a). Diffusion is the process by which ionic or molecular constituents move under the influence of concentration gradients. Mechanical dispersion occurs as the groundwater flows through the media, and compounds spread out through the tortuous pathways of the soil matrix preferentially along higher conductive

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pathways, and mix with clean water. Dispersion, or spreading out of the contaminant, may occur in longitudinal, lateral, and vertical aspects of the migration pathway. The result of this dispersion is a dilution of the compound (Fetter, 1988). At extremely low groundwater velocities (i.e., in clayey silts), diffusion may be the dominant process; at higher velocities, mechanical dispersion is likely the dominant process. Dispersivity (a measure of the probable dispersion) is dependent on vertical and horizontal permeability variations, increasing with the degree of heterogeneity and anisotropy, and is also dependent on whether flow is through porous media or nonporous media (e.g., fractured bedrock) (Walton, 1988).

The rate a compound migrates can be influenced by facilitated transport, which is the combined effects of physical, chemical, and/or biological phenomena that act to increase mobility. Examples of facilitated transport include particle transport, cosolvation, and phase shifting (Keely, 1989).

Particle transport involves the movement of small, particles (such as inorganic and organic colloids), macromolecules, or emulsions to which compounds have adhered by sorption, ion exchange, or other means. High molecular weight organic compounds such as PAHs, pesticides, and heavy metals, have a high affinity for mobile subsurface particles, and this affinity increases their mobility (Huling, 1989). Small particles, especially mobile organic carbon phase particles such as biocolloids and macromolecules (e.g., humic substances) are transported in the aqueous phase and may act as mobile sorbents.

Cosolvation is the process by which the solubility and mobility of one compound is increased by the presence of another (Keely, 1989). Naturally occurring organic compounds (e.g., humic acids) can undergo complexation reactions with metals and pesticides. Complexation reactions can increase the solubility of metals (including iron, aluminum, copper, nickel, and lead) and pesticides (e.g., DDT). In a cosolvent system, as the fraction of a water-miscible cosolvent increases, the solubilities of the metals or pesticides increase. However, the cosolvent concentration normally needs to be high to ensure a substantial increase in solute velocity. Therefore, cosolvation is important primarily near sources of groundwater impact (USEPA, 1989a). High concentrations of water-miscible phases (e.g., ketones) were not detected at AOC 41.

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Chemical phase shifts involve changes in pH and/or the redox potential of the groundwater. These shifts can increase solubilities and mobilities by ionizing neutral organics, solubilizing precipitated metals, forming complexes, or limiting biological activity (Keely, 1989). These processes are particularly important in determining the mobility of heavy metals. Inorganics and heavy metals are not compounds of concern at AOC 41.

Processes that tend to attenuate migration of impacted groundwater include retardation resulting from sorption, volatilization, degradation, and precipitation. The sorption properties of individual solutes are dependent on soil and groundwater characteristics. In general, the relative amount of sorption by soil or sediment materials that do not contain organic matter is as follows: clay > silt > sand > gravel (Walton, 1988). The soil beneath AOC 41 is a clayey silt. Sorption would be expected to exert a significant influence in retarding the migration of VOCs and SVOCs in the till.

The tendency of organic chemicals to be sorbed is also dependent on the organic content of the soil and the degree of hydrophobicity (lack of affinity for water) of the solute. The rate of travel for each chemical depends on the groundwater seepage velocity and the degree of sorption. If an organic chemical is extensively sorbed by the soil matrix particles, it will be rendered relatively immobile. The rates and degree of volatilization, photolysis, hydrolysis, and biodegradation are directly dependent on the extent of sorption (Montgomery, 1991). The vadose zone typically contains greater amounts of organic material and metal oxides (which may also act as sorbents) than the saturated zone, which may make the rate of movement in the vadose zone substantially less than that in the saturated zone (USEPA, 1989a).

The soil/sediment partition or sorption coefficient (K_{oc}) is defined as the ratio of adsorbed chemical per unit weight of organic carbon to the aqueous solute concentration. The coefficient indicates the tendency of a compound to sorb to organic carbon (degree of retardation); and therefore, provides a means for estimation of the relative mobility of solutes (Montgomery, 1991). Mobility is a function of the relative rate of transport of a chemical versus the rate of groundwater flow. Chemicals that have relatively low mobilities (i.e., high retardation or sorption) move slowly compared to the velocity of the groundwater. Chemicals that have relatively high mobilities (i.e., low retardation or sorption)

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move at a rate closer to groundwater velocity. VOCs detected at AOC 41 have relatively high mobility potential, while SVOCs have a low to moderate mobility potential (see Table 8-1).

Volatilization is the transport of a compound from the liquid to the vapor phase and, ultimately, into the atmosphere. Volatilization rates are affected by soil properties, vapor pressure, temperature, and sorption. VOCs partition between the aqueous and gaseous phase in unsaturated soils. This process will occur most readily for compounds with a high vapor pressure and a high H . These compounds tend to partition off into the gas phase and occupy the available soil pore space. In addition, VOCs in the saturated zone or in surface water will partition to the gaseous phase, particularly those with lower solubility (e.g., xylenes). VOCs with greater aqueous solubility tend to remain in solution.

Volatilization is an important process in shallow soils and surface water. In recharge areas composed of sandy or gravelly soil, volatilization may be an important process, especially for compounds with moderate to high volatility (Montgomery, 1991). The effectiveness of volatilization normally decreases with depth in the soil column.

Chemicals released to the environment are susceptible to several degradation pathways, including chemical degradation (e.g., oxidation and reduction); photolysis or photochemical degradation; and biodegradation. Compounds formed by these processes may be more or less toxic and/or more or less mobile than the parent compound.

Oxidation typically involves the loss of electrons during a chemical reaction. In general, substituted aromatic compounds such as ethylbenzene can be oxidized. Oxidation rates for aromatic compounds are typically an order of magnitude faster than for chlorinated aliphatic compounds (e.g., cis-1,2-DCE). Overall, abiotic (without biological life) oxidation of organic compounds in groundwater systems is extremely limited.

In anaerobic environments, reductive dehalogenation of chlorinated VOCs can occur. For a chlorinated VOC such as TCE, this process, known as hydrogenolysis results in a less chlorinated compound (e.g., the formation of 1,2-DCE from TCE). Hydrogenolysis is defined as a reduction in which a

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halogen-carbon bond is broken, and hydrogen replaces the halogen substituent. These reactions are most likely to occur in groundwater with low dissolved oxygen (DO). Under the aerobic conditions expected in the unsaturated soil and surface water, the process of reductive dehalogenation is expected to be slow, and the primary fate mechanism for chlorinated VOCs will be volatilization.

Photochemical breakdown processes involve structural changes in a molecule induced by radiation in the ultraviolet-visible light range. This process is unlikely to occur at AOC 41 due to contamination being confined to the subsurface environment.

Biodegradation may be defined as the breakdown of organic compounds by microorganisms through metabolic processes. Variables affecting the rate of biodegradation include:

- Number of microorganisms (most are within 14 centimeters of the ground surface)
- Chemical properties, concentrations, and distribution
- Presence of food and nutrients
- Temperature
- pH
- Moisture and oxygen content

The rate of biodegradation tends to be higher for low molecular weight compounds. Naturally occurring soil and aquatic microorganisms capable of degrading aromatic hydrocarbons (e.g., benzene, toluene, ethylbenzene, and xylene) have been studied, and a relationship between DO and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized by dissolution from soil or sediment, they are likely to be rapidly degraded as long as microorganisms and DO are available.

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8.2 FATE AND TRANSPORT OF CONTAMINANTS DETECTED AT AOC 41

This subsection discusses the potential fate and transport of contaminants detected at AOC 41. The primary focus is on chlorinated VOCs detected in groundwater at AOC 41.

Groundwater samples collected at AOC 41 contained the chlorinated VOCs cis-1,2-DCE, TCE, and 1,1,2,2-TCA. TCE was detected at concentrations up to 200 $\mu\text{g/L}$; cis-1,2-DCE was detected at concentrations up to 1.8 $\mu\text{g/L}$; and 1,1,2,2-TCA was detected at concentrations up to 34 $\mu\text{g/L}$. No source of chlorinated VOCs was defined in the subsurface soils at AOC 41.

The fate and transport of organic compounds found at AOC 41 may be viewed with regard to one chemical group, chlorinated VOCs. Chlorinated VOCs detected at AOC 41 are characterized by straight-chain structures; a variable number of single and double bonds; and the presence of chlorine. Chlorinated VOCs have many applications, such as solvents, degreasers, dry cleaning agents, gasoline additives, refrigerants, and organic synthesis agents (Moore and Ramamoorthy, 1984). Chlorinated VOCs tend to have high solubilities, high volatilities, low to moderate partition coefficients, high mobilities, and densities greater than water. As a result, they are relatively easily volatilized into the atmosphere (if conditions are suitable), or leached from soil into groundwater.

The fate of chlorinated VOCs in soil and groundwater is a function of the solubility, volatility, sorption, and degradation. Because of their high volatility, moderate to high solubility, and low adsorption to soils, chlorinated VOCs are relatively mobile and nonpersistent in soil systems. The volatile nature of TCE and cis-1,2-DCE coupled with the relatively coarse-grained texture of the shallow unsaturated soils at AOC 41, makes these compounds susceptible to volatilization.

With releases of chlorinated VOCs onto porous soils such as those found at AOC 41, the VOCs may not evaporate before penetrating the soil, and may possibly enter the water table as a non-aqueous phase liquid (NAPL). The NAPL must generate sufficient entry pressure (thickness) to penetrate into the water table for soils with lower permeability.

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Once in the subsurface, the chlorinated VOCs may undergo reductive dehalogenation. Although the time required for each step may vary widely and degradation may or may not occur, depending on conditions (normally anaerobic), TCE may be progressively broken down to cis-1,2-DCE, vinyl chloride, and, possibly, to carbon dioxide. Several studies report that the isomer cis-1,2-DCE is formed preferentially to trans-1,2-DCE. One possible explanation is that during reductive dechlorination, a chloride ion and free radical are formed. Because water is typically the medium in which the reaction occurs, the most polar form of the radical is favored (cis-1,2-DCE). Analytical groundwater data indicates that cis-1,2-DCE is the predominant isomer. Vinyl chloride forms from the reductive dechlorination of cis-1,2-DCE. Vinyl chloride was not detected in groundwater samples collected from AOC 41.

1,1,2,2-TCA may be transformed to 1,1,1-trichloroethane under certain environmental conditions. 1,1,1-trichloroethane was not detected in soil or groundwater analytical samples at AOC 41.

Furthermore, the relative rate of dechlorination of these chlorinated VOCs decreases as chlorines are sequentially removed. Therefore, the rate of degradation of TCE is more rapid than that of the 1,2-DCE isomers, and reductive dechlorination of vinyl chloride may not be observed. As such, vinyl chloride is relatively persistent and the formation of carbon dioxide or ethylene is rather slow. Carbon dioxide is the general end product of organic degradation (oxidation).

The fate of the SVOCs detected at relatively low concentrations in two test pits is expected to be reduction through volatilization and biodegradation. The SVOCs would be expected to eventually partition out of the aqueous phase to the soil phase and remain present in the soils. The slow rate of migration (due to partitioning to soil) of the SVOCs allows for significant degradation, even if degradation rates are small, before they can travel significant distances. The SVOCs detected tend to be more persistent with increasing molecular weight.

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8.3 SITE CONCEPTUAL MODEL

The site conceptual model is designed to simply present the essential features of AOC 41. Based on the results of the previous investigations the primary site-related contaminants are chlorinated solvents in groundwater. The solvents detected above applicable drinking water standards/guidelines were 1,1,2,2-TCA, PCE, and TCE. These compounds were detected in groundwater samples collected during all six rounds of groundwater sampling. Several inorganics were also detected above their applicable drinking water standards/guidelines in the unfiltered samples collected during each round of sampling. The inorganic results for the filtered groundwater samples collected during Rounds Two through Six indicated that the inorganic concentrations in the unfiltered samples were a result of TSS, and are not considered site-related contaminants.

Based on the results of the field investigations, it is unclear what the source of the chlorinated solvent detected in the groundwater may be. However, it appears that the source of the solvent contamination is within the area investigated at AOC 41.

The primary release mechanism appears to be contaminants leaching from the sources and into the soil below. A potential secondary source of groundwater contamination at AOC 41 appears to be solvent contaminants in the soil below the primary source.

The secondary release mechanism appears to be via contaminant volatilization, infiltration and/or percolation through the unsaturated subsurface soil and to the water table.

The migration pathways/transport mechanisms for the contaminants detected in groundwater appear to be dissolved contaminants in groundwater.

Based on the data collected at AOC 41, it appears that base personnel and training personnel could be affected by the VOC contaminants through ingestion, direct contact, and inhalation of contaminated groundwater if the contaminants migrated to the South Post Water Point (Well D-1). However, based upon the

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local and regional hydrologic conditions, it does not seem likely that the VOC contaminants detected at AOC 41 could migrate to Well D-1. In addition, it does not appear that ecological receptors in New Cranberry Pond would be impacted by the contaminants detected in the groundwater at AOC 41.

TABLE 8-1
CHEMICAL AND PHYSICAL PROPERTIES OF COMPOUNDS DETECTED
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIATION INVESTIGATION REPORT
FORT DEVENS, MA

CONTAMINANT	MOLECULAR WEIGHT	DENSITY (g/cm ³)	WATER SOLUBILITY (mg/L)	VAPOR PRESSURE (mm Hg)	HENRY'S CONSTANT, H _{oc} (atm m ³ mol ⁻¹)	ORGANIC CARBON PARTITION COEFFICIENT K _{oc} (mL/g)
VOLATILE ORGANIC COMPOUNDS						
1,1,2,2-TETRACHLOROETHANE	167.9	1.6	2.90E+03	5.00E+00	3.81E-04	1.18E+02
CIS-1,2-DICHLOROETHENE	98.98	1.28	8.52E+03	6.40E+01	7.58E-03	1.40E+01
TETRACHLOROETHENE	165.8	1.63	1.50E+02	1.78E+01	2.59E-02	3.64E+02
TRICHLOROETHENE	131.4	1.47	1.10E+03	5.79E+01	9.1E-03	1.26E+02
XYLENES ^a	106.2	0.88	1.75E+02	6.60E+00	7.04E-03	8.30E+02
TOLUENE	92.13	0.86	5.35E+02	2.81E+01	6.37E-03	3.00E+02
SEMIVOLATILE ORGANIC COMPOUNDS						
ACENAPHTHENE	152	0.9	3.93E+00	2.50E+03	9.20E-05	2.50E+03
ANTHRACENE	178.2	1.24	4.50E-02	1.95E-04	1.02E-03	1.40E+04
BENZO(A)ANTHRACENE	228.3	1.27	5.70E-03	2.20E-08	1.16E-06	1.38E+06
BENZO(A)PYRENE	252.3	1.35	3.80E-03	5.60E-09	1.55E-06	5.50E+06
BENZO(B)FLUORANTHENE	252.3	NA	1.40E-02	5.00E-07	1.19E-05	5.50E+05
BENZO(G,H,I)PERYLENE	276	NA	2.60E-04	1.03E-10	5.34E-08	1.60E+06
BENZO(K)FLUORANTHENE	252.3	NA	4.30E-03	5.10E-07	3.94E-05	5.50E+05
CHRYSENE	228.3	1.07	1.80E-03	6.30E-09	1.05E-06	2.00E+05
FLUORANTHENE	202.3	1.25	2.60E-01	5.00E-06	6.50E-06	3.80E+04
INDENO(1,2,3-CD)PYRENE	276.3	NA	5.30E-04	1.00E-10	6.86E-08	1.60E+08
NAPHTHALENE	128.2	0.98	3.17E+01	2.30E-01	1.15E-03	1.30E+03
PHENANTHRENE	178.2	1.03	1.00E+00	6.80E-04	1.59E-04	1.40E+04
PYRENE	202.3	1.27	1.30E-01	2.50E-06	5.04E-06	3.80E+04
PESTICIDES						
CHLORDANE	409.8	NA	5.6E-05	4.6E-04	9.63E-06	2.50E+04
DDD	320	NA	1.00E-01	1.89E-06	7.96E-06	7.70E+05
DDE	318	NA	4.00E-02	6.50E-05	6.80E-05	4.40E+06
DDT	354.5	0.98	5.00E-03	5.50E-06	5.13E-04	2.43E+05
HEPTACHLOR	373.3	1.57	1.8E-04	4.0E-04	8.19E-04	1.20E+04
ENDRIN	380.9	NA	2.5E-04	3.00E-06	4.20E-06	3.40E+04

Notes:

- Primary Source: USEPA, 1990. "Basics of Pump-and-Treat Ground-Water Remediation Technology." Robert S. Kerr, Environmental Research Laboratory, Ada, OK. EPA/600/8-90/003.
 - Data presented is for o-xylene.
- NA = Not available
- Aubrey, D. C., 1993. "Encyclopedia of Chemical Technology." Fourth Edition. John Wiley and Sons, New York, NY.
- Verschueren, Karel, 1983. "Handbook of Environmental Data on Organic Chemicals." Van Nostrand Reinhold Company, Inc.
- Howard, Philip, 1990. "Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume II, Solvents." Lewis Publishers, Inc.

TABLE 8-2
MOBILITIES OF INORGANIC ELEMENTS
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

Relative Mobility	Environment		
	Oxidizing (pH 5 to 8)	Oxidizing (pH <4)	Reducing
Highly mobile	Anions, B, Mo	Anions, B	Anions
Moderately mobile	Ca, Na, Mg, Sb, As, V, Zn, Be	Ca, Na, Mg, Pb, Zn, Cu, Hg, Co, Ni, V, As, Mn, Cd, Sb	Ca, Na, Mg, Ba, Mn
Slightly mobile	K, Ba, Mn, Pb, Cu, Cd, Ni	K, Ba, Cr	K, Fe ²⁺
Immobile	Fe, Al, Cr, Hg	Fe, Al	Fe ³⁺ , Al, Cu, Zn, Pb, Cr, V, Ni, As*, Sb, Cd, Hg, Ba

*Mobile in slightly reducing conditions.

As = Arsenic
Al = Aluminum
B = Boron
Ba = Barium
Be = Beryllium
Ca = Calcium
Cd = Cadmium
Co = Cobalt
Cr = Chromium
Cu = Copper
Fe = Iron
Hg = Mercury
K = Potassium
Mg = Magnesium
Mn = Manganese
Mo = Molybdenum
Nd = Sodium
Ni = Nickel
Pb = Lead
Sb = Antimony
V = Vanadium
Z = Zinc

Source:

Rose, A.W., H.E. Hawkes, and J.S. Webb, 1979. Geochemistry in Mineral Exploration. Academic Press.

9.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The focus of the baseline human health risk assessment for AOC 41 is the groundwater operable unit at AOC 41, the subject of this RI. Other media including soil, sediment, and surface water have been sampled in earlier investigations at AOC 41, but these media will not be included in the baseline risk assessment, due to physical site features (surface water/sediment) or inclusion in remedial alternatives which are not part of this operable unit. Based on the findings presented in the previous sections, it is clear that the waste material found at AOC 41 is not the source of the groundwater contamination. However, it does appear that the source does reside within the area investigated during the RI. Previous investigations at AOC 41 include the following:

- *SI Data Packages, Fort Devens, Groups 2, 7, and Historic Gas Stations*, January 1993. Prepared by ABB-ES for the US Army Toxic and Hazardous Materials Agency (now the USAEC, ABB-ES, 1993d).
- *Final Site Investigation Report, Fort Devens, Groups 2, 7, and Historic Gas Stations*, May 1993. Prepared by ABB-ES for the USAEC (ABB-ES, 1993a).
- *Supplemental Site Investigation Data Package, Fort Devens, Groups 2, 7, and Historic Gas Stations*, January 1994. Prepared by ABB-ES for the USAEC (ABB-ES, 1994a).

An evaluation of the health risks associated with exposure to soil at AOC 41 will not be included in the baseline risk assessment. Surface soil at AOC 41 will be addressed separately under the Fort Devens landfill consolidation study. Subsurface soil will not be addressed in this baseline risk assessment due to the lack of an exact location of a contaminant source area. Although surface water and sediment at New Cranberry Pond were sampled during previous investigations, it has been demonstrated in Section 5.0 that surface water from New Cranberry Pond recharges groundwater below AOC 41, and, therefore, it appears that site-related contaminants from AOC 41 are not impacting ecological receptors in New Cranberry Pond.

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Groundwater associated with AOC 41 is not currently used for drinking water or for any other purpose. Except for the Fort Devens South Post Water Point (Well D-1), groundwater on the South Post (where AOC 41 is located) does not represent a current or potential future source of drinking water. The South Post is an area of Fort Devens used mainly for the field training of active duty and reserve troops. The area around AOC 41 is used as a antitank weapon firing range. The South Post, including the area around AOC 41, will be retained by the Army, and will continue to be used for training activities (BRAC, 1991). Therefore, future land and groundwater uses will remain the same as the current uses.

Well D-1 is located on Dixie Road in the South Post east of Echo Range (E) near the north end of Alpha Range (A) (Figure 9-1). Well D-1 is approximately 2,500 feet north and slightly west of AOC 41. Based on the presumed local and regional groundwater flow (as discussed in Section 6.0), Well D-1 would not be expected to be impacted by the contaminants in groundwater at AOC 41.

Groundwater use and quality at Fort Devens was summarized in the *Final Remedial Investigations Report, Functional Area I, Fort Devens, Massachusetts*, prepared by Ecology and Environment, Inc. in August 1994 (E&E, 1994). The RI for Functional Area I includes three AOCs (25, 26, and 27) on the South Post. In addition to Well D-1, which supplies potable water to troops who train on the South Post, four additional water supply sources exist on the Main and North Posts of Fort Devens which supply drinking water for those portions of the installation.

Fort Devens withdraws groundwater from two wells on the Main Post (the Sheboken and Patton wells), one well on the North Post (the McPherson well), and a well field known as the Grove Pond Wellfield on the Main Post (see Figure 9-1).

The Sheboken well was constructed in 1941 and is located at Building 3628 on the Main Post, along Sheridan Road north of Route 2. The Patton well, constructed in 1953, is located at Building 3630 on the Main Post, north of Mirror Lake along Patton Road. The McPherson well, constructed in 1966, is located on the North Post, east of McPherson Road and the Nashua River and north of Verbeck Gate. These three wells have a rated capacity of 1,000 gpm. The Grove Pond Wellfield consists of eight wells that are in use and is rated for a capacity of 600 gpm. The wellfield is situated on the south shore of Grove Pond on the Main Post. The

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wellfield is reported to be used on a regular basis every three months but is not used continuously (E&E, 1994).

In the RI for Functional Area I, E&E reported that groundwater supplies at Fort Devens have consistently met Massachusetts water quality standards. Except for sodium, the physical and chemical qualities of on-site potable water have complied with state standards. The installation has been complying with the state regulation for reporting sodium concentrations in excess of 20 milligrams per liter (mg/L). The sodium notification requirement is designed to alert persons on a sodium-restricted diet of high sodium levels in their drinking water.

E&E also reported that Well D-1 is used to supply troops on the South Post who spend no more than two weeks per year on the South Post. There are 24 training areas on the South Post where bivouac operations (establishing temporary encampments) are authorized. Usage records reviewed by E&E for these 24 training areas for a one-year period were assembled using a computer program used by Fort Devens South Post Range Control. These records indicate that, on average, units were bivouacked at one of the South Post training areas for 5.53 days. The majority of the training units were from the 10th Special Forces which will be departing Fort Devens under the BRAC. Overnight training exercises are expected to continue by National Guard Units, Reserve Units, and ROTC units with similar levels of use (E&E, 1994).

Table 9-1 summarizes the analytical data from the sampling of Well D-1 water. (Analytical data in Table 9-1 have been extracted from Table 8-5 in the RI for Functional Area I [E&E, 1994]. This well has been sampled by E&E and ABB-ES four times since 1991. For comparison, Table 9-1 contains detected inorganic analytes in a local background well for the EOD Range, 25M-92-05X, as well as basewide background concentrations for inorganics reported in ABB-ES, 1993d. The following metals were detected in Well D-1 at concentrations exceeding their local background values: arsenic, calcium, lead, magnesium, sodium, and zinc. However, only the maximum detected concentration of zinc (40.5 $\mu\text{g/L}$) exceeds its basewide background concentration (21.1 $\mu\text{g/L}$).

Appendix N contains a copy of the quantitative risk assessment conducted by E&E for Well D-1 on the South Post. E&E calculated the noncarcinogenic risks (as hazard indices) and carcinogenic risks associated with the contaminants detected in

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Well D-1 and reported in Table 9-1. The exposure frequency was assumed to be 14 days per year. Cancer risks were calculated for two possible exposure durations (ED): 10 years, which is probably greater than any individual exposure, and two years, which is more typical.

Table 9-2 presents the risk estimates reported by E&E (see Appendix N). A USEPA Office of Solid Waste and Emergency Response (OSWER) directive, the "Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions", indicates that action is generally warranted at a site when carcinogenic risks are greater than 1×10^{-4} or noncarcinogenic hazard indices (HIs) exceed 1 (based on Reasonable Maximum Exposure assumptions). USEPA Superfund guidelines also state that when the total incremental carcinogenic risk for an individual resulting from exposure at a hazardous waste site is within the range of 1×10^{-4} to 1×10^{-6} , a decision about whether to take action or not is a site-specific decision. This range of 1×10^{-4} to 1×10^{-6} is often referred to as the Superfund target risk range.

As seen in Table 9-2, all of the HIs are well below the USEPA threshold of 1, indicating that there are no unacceptable noncarcinogenic health risks. The carcinogenic risks are all below 1×10^{-4} . For one exposure scenario, assuming a 10 year ED, the cancer risk slightly exceeds 1×10^{-6} , at 1.3×10^{-6} . This cancer risk is, however, at the low end of the Superfund target risk range. E&E concluded that there are no unacceptable risks to human health from the groundwater at the South Post Well D-1, and that no further action would be required under CERCLA.

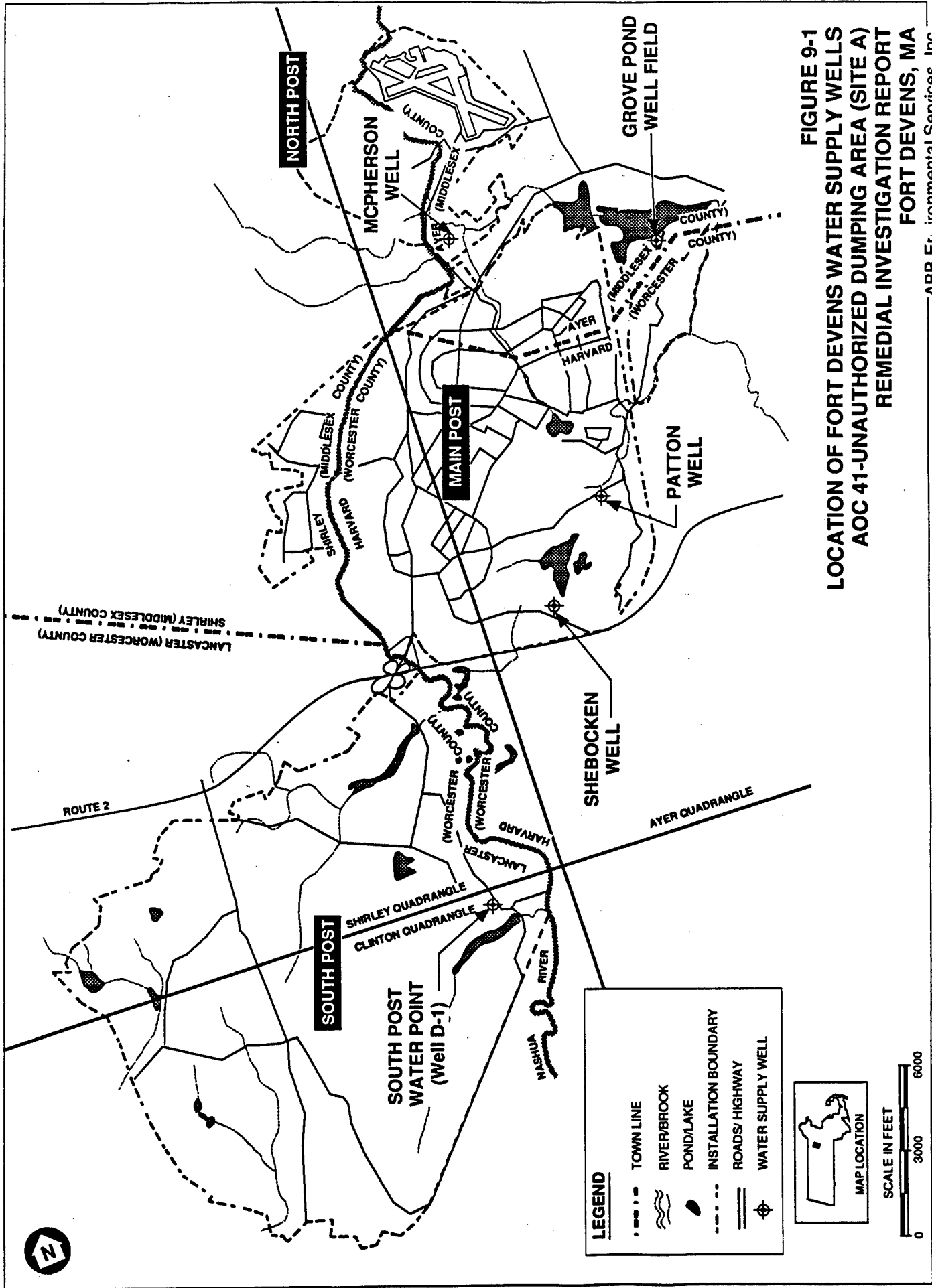


TABLE 9-1
SUMMARY OF SAMPLING RESULTS FOR WELL D-1¹ ($\mu\text{g/L}$)
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	DETECTION FREQUENCY	RANGE		LOCAL BACKGROUND 25M-92-05X	BASEWIDE BACKGROUND ²	MAXIMUM EXCEEDS BACKGROUND ²
		MINIMUM	MAXIMUM			
Inorganics						
Arsenic	2/4	3.80	4.56	<2.54	10.5	No
Barium	1/4		2.12	13.2	39.6	No
Calcium	4/4	5,480	6,200	2,745	14,700	No
Copper	1/4		6.73	<8.09	8.09	No
Iron	4/4	113	188	2,640	9,100	No
Lead	2/4	2.17	4.23	1.85	4.25	No
Magnesium	4/4	1,560	1,760	914	3,480	No
Manganese	3/4	3.18	4.02	68.6	291	No
Potassium	4/4	568	1,380	1,575	2,370	No
Sodium	3/4	2,470	2,640	2,105	10,800	No
Zinc	1/4		40.5	<21.1	21.1	Yes
Pesticides						
Endosulfan sulfate	1/4		0.260	NA	NA	-
Endosulfan, B	1/4		0.006	NA	NA	-
Semivolatile Organics						
2-Ethyl-1-hexanol	1/4		10.0	NA	NA	-
Bis(2-ethylhexyl)phthalate	2/4	10.0	53.0	NA	NA	-
Hexanedioic acid dioctylester	1/4		9.0	NA	NA	-
Volatile Organics						
Chloroform	1/4		1.70	NA	NA	-

Key:

NA = Not applicable

¹ Source: Ecology and Environment, Inc., 1994.

² Source: ABB-ES, 1993

Shaded line indicates exceedance by maximum of both local background and basewide background.

TABLE 9-2
RISKS FROM USE OF WELL D-1 GROUNDWATER
AOC 41 - UNAUTHORIZED DUMPING AREA (SITE A)

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

ANALYTE	MAXIMUM CONCENTRATION DETECTED ($\mu\text{G/L}$)	NON-CARCINOGENIC RISKS (HI)	CARCINOGENIC RISKS	
			CANCER RISK 10 YEARED	CANCER RISK 2 YR ED
Arsenic	4.56	1.7×10^{-2}	1.3×10^{-6}	2.6×10^{-7}
Barium	2.12	3.3×10^{-5}	-	-
Copper	6.73	2.0×10^{-4}	-	-
Manganese	4.02	8.8×10^{-4}	-	-
Zinc	40.5	1.5×10^{-4}	-	-
Bis(2-ethylhexyl)phthalate ¹	53.0	2.9×10^{-3}	1.2×10^{-7}	2.3×10^{-8}
Endosulfan Sulfate	0.26	4.8×10^{-5}	-	-
Endosulfan, B	0.006	1.1×10^{-6}	-	-
Chloroform	1.70	1.9×10^{-4}	1.6×10^{-9}	3.2×10^{-10}

¹ Bis(2-ethylhexyl)phthalate is thought to result from sampling or laboratory contamination.

10.0 CONCLUSIONS AND RECOMMENDATIONS

RI activities were conducted by ABB-ES personnel at AOC 41 to evaluate the nature and distribution of the groundwater contamination detected during previous investigations. A summary of the RI activities and findings is presented in the following subsections.

10.1 CONCLUSIONS

The following conclusions are based on interpretation of data collected from each of the previous investigations (SI, SSI and RI) completed at AOC 41.

- The geologic setting at AOC 41 includes an upper sand layer underlain by a discontinuous clayey silt layer, a lower silty sand layer, and finally a lower sand layer. Bedrock was not encountered in any of the borings completed at AOC 41.
- The aquifer below AOC 41 can be classified as an unconfined overburden groundwater aquifer. The aquifer is recharged by surface water infiltration and percolation, and recharge from surface water from New Cranberry Pond. This hydraulic condition is caused by a road culvert located at the eastern end of the pond which artificially raises the surface water elevation in the pond, thus causing the surface water to recharge groundwater below AOC 41. The predominant local groundwater flow at AOC 41 is to the north-northeast, eventually discharging into the Nashua River.
- Groundwater at AOC 41 is contaminated with several VOCs. However, three VOCs (1,1,2,2-TCA, PCE and TCE) have been found to have the widest dispersion and concentrations. 1,1,2,2-TCA was detected at a maximum concentration of 170 $\mu\text{g/L}$, PCE was detected at a maximum concentration of 10 $\mu\text{g/L}$ and TCE at a maximum concentration of 220 $\mu\text{g/L}$. The groundwater results also indicated that several inorganics (aluminum, arsenic, beryllium, chromium, cobalt, iron, lead, manganese, and nickel) were present

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in unfiltered groundwater samples above the established Fort Devens background and drinking water standards. However, a comparison of these results to filtered groundwater samples and TSS concentrations indicate that the unfiltered concentrations are a likely result of suspended solids and not dissolved site-related contaminants.

No obvious source of the VOC contamination was precisely located, however, it was determined that the waste material located at AOC 41 was not the source.

The results of the RI groundwater sampling and the field analysis completed during the RI, indicate that the existing groundwater contaminant plume appears to be confined to the upper portion (water table) of the aquifer and it is oriented in a northeast-southwest direction. Based on the chemical properties of the contaminants, the slow rate of groundwater flow in the clayey silt, and the existing downgradient groundwater results (41M-94-09A and B), it appears that the distribution of the groundwater contamination has been determined, and that contaminant migration to any exposure point (Well D-1) is minimal.

- Surface water and sediment from New Cranberry Pond were sampled during previous investigations. However, data collected during the SSI and the RI, demonstrate that New Cranberry Pond surface water recharges groundwater below AOC 41. An assessment of the potential surface soil migration pathways showed that no migration pathway (i.e., overland transport of surface soil via surface water) exists between the contaminants detected in the surface soil on the waste material and New Cranberry Pond surface water and sediment. Because of these reasons, the previous surface water and sediment data was not evaluated in the RI.
- The base-line human health risk assessment was limited to an evaluation of the exposure potential to groundwater at AOC 41, and a summary of E&Es quantitative risk evaluation for groundwater from Well D-1. E&E concluded that there are no unacceptable

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risks to human health from the groundwater at Well D-1 for troops that consume the water for approximately 14 days per year, and that no further action would be required under CERCLA.

10.2 RECOMMENDATIONS

Based on the results and interpretation of the physical and chemical data and taking into account that the future land and groundwater use of this AOC will be similar to the present use, ABB-ES recommends that the Army complete a monitoring ROD and Proposed Plan for the groundwater at AOC 41 to include the AOC 41-related contaminants in the analysis of the groundwater samples from Well D-1.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ABB-ES	ABB Environmental Services, Inc.
ANL	Argonne National Laboratory
AOC	Area of Contamination
ARAR	Applicable or Relevant and Appropriate Requirement
ARF	Analysis Request Form
BEHP	bis (2-ethylhexyl)phthalate
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
cm/sec	centimeters per second
CMR	Code of Massachusetts Regulations
COC	Chain-of-Custody
CRL	Certified Reporting Limits
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
4,4-DDD	dichlorodiphenyl dichloroethane
4,4-DDE	dichlorodiphenyl dichloroethene
DO	dissolved oxygen
DQO	Data Quality Objectives
E&E	Ecology & Environment, Inc.
ED	exposure duration
ELCD	electrolytic conductivity detector
ETA	Engineering Technologies Associates, Inc.
°F	Fahrenheit
FFA	Federal Facility Agreement
FID	flame ionization detector
FS	Feasibility Study
FSP	Field Sampling Plan
ft ² /day	square feet per day

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

GC	gas chromatograph
GPM	gallons per minute
H	Henry's Law Constant
HASP	Health and Safety Plan
HI	hazard indices
HSA	hollow-stem augers
ID	inside diameter
IDW	investigation-derived waste
IR	infrared spectrometer
IRDMIS	Installation Restoration Data Management Information System
K _{oc}	organic carbon coefficient
MAAF	Moore Army Airfield
MADEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
MCLG	maximum containment level goal
MCP	Massachusetts Contingency Plan
MDL	method detection limit
MEP	Master Environmental Plan
mg/L	milligrams per liter
mL	milliliter
MMCL	Massachusetts Maximum Containment Level
mph	miles per hour
MS	mass spectroscopy
MS/MSD	matrix spike/matrix spike duplicate
NAPL	nonaqueous phase liquid
NCP	National Contingency Plan
NWR	National Wildlife Refuge
OSHA	Occupational Safety and Health Administration

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

PAH	polynuclear aromatic hydrocarbon
PAL	Project Analyte List
PARCC	precision, accuracy, representativeness, completeness, and comparability
PC	personal computer
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
POP	Project Operations Plan
ppb	parts per billion
PQL	Practical Quantitation Limit
PRE	preliminary risk evaluation
PRI	Potomoc Research, Inc.
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAS	Routine Analytical Services
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
ROTC	Reserve Officer Training Corps.
RPD	relative percent difference
SA	Study Area
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SI	Site Investigation
SPIA	South Post Impact Area
SSI	Supplemental Site Investigation
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

TCE	trichloroethene
TBC	to be considered
TIC	tentatively identified compound
TOC	Total Organic Carbon
TPHC	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
µg/g	micrograms per gram
µg/L	micrograms per Liter
USAEC	U.S. Army Environmental Center
USATHAMA	U.S. Army Toxic Hazardous Materials Agency
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UXO	unexploded ordnance
VOC	volatile organic compound
WPA	Works Progress Administration

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REFERENCES

- ABB Environmental Services, Inc., 1992a. "Draft Final Project Operations Plan for Site Investigations and Remedial Investigations, Fort Devens, Massachusetts"; Data Item A005/A008; Prepared for Commander, U.S. Army Toxic and Hazardous Materials Agency; prepared by ABB Environmental Services, Inc., Portland, Maine; July.
- ABB Environmental Services, Inc., 1992b. "Site Investigation Work Plan - Groups 2 and 7, Fort Devens, Massachusetts, Final Task Order Work Plan", and "Site Investigation Work Plan - Historic Gas Stations, Fort Devens, Massachusetts, Final Task Order Work Plan"; Data Item A004; Prepared for Commander, U.S. Army Toxic and Hazardous Materials Agency; prepared by ABB Environmental Services, Inc., Portland, Maine; December.
- ABB Environmental Services, Inc. (ABB-ES), 1993a. "SI Data Packages, Fort Devens, Groups 2, 7, and Historic Gas Stations." Prepared by ABB-ES for the US Army Toxic and Hazardous Materials Agency (now the AEC). January 1993.
- ABB Environmental Services, Inc., 1993b. "Final Site Investigation Report - Groups 2, 7, and Historic Gas Stations, Fort Devens, Massachusetts"; Data Item A009; Prepared for Commander, U.S. Army Environmental Center; prepared by ABB Environmental Services, Inc., Portland, Maine; May 1993.
- ABB Environmental Services, Inc. (ABB-ES), 1993c. "Final Remedial Investigation Addendum Report, Fort Devens Feasibility Study for Group 1A Sites." Prepared for US Army Environmental Center. December 1993.
- ABB Environmental Services, Inc., 1993d. "Final Supplemental Site Investigations Work Plan - Groups 2 and 7, Fort Devens, Massachusetts, Final Task Order Work Plan"; Data Item A004; Prepared for Commander, U.S. Army Environmental Center; prepared by ABB Environmental Services, Inc., Portland, Maine; May, revised July 30, 1993.

ABB Environmental Services, Inc.

REFERENCES

- ABB Environmental Services, Inc., 1993e. "Final Project Operations Plan for Site Investigations and Remedial Investigations, Fort Devens, Massachusetts"; Data Item A005/A008; Prepared for Commander, U.S. Army Environmental Center; prepared by ABB Environmental Services, Inc., Portland, Maine; July.
- ABB Environmental Services, Inc., 1994a. "Supplemental Site Investigation Data Package, Fort Devens, Groups 2 and 7, and Historic Gas Stations. Prepared by ABB-ES for the U.S. Army Environmental Center 9AEC). January 1994.
- ABB Environmental Services, Inc., 1994b. "Revised Final Task Order Work Plan Area of Contamination (AOC) 41, AOC 43G, and AOC 43J;" Data Item A004; Prepared for Commander, U.S. Army Environmental Center; Prepared by ABB Environmental Services, Inc., Portland, Maine; October 1994.
- ABB Environmental Services, Inc., 1995. "Project Operations Plan." Data Item A004/A006; Prepared for Commander, U.S. Army Environmental Center; prepared by ABB Environmental Services, Inc., Portland, Maine; May.
- Alden, W.C., 1925. "Physical Features of Central Massachusetts." In *Contributions to the Geography of the United States, 1923-1924*. U.S. Geological Survey Bulletin 760, pp. 13-106.
- Arthur D. Little, Inc. (ADL), 1994a. Addendum 1 - AREE River Evaluation. Base Realignment and Closure Environmental Evaluation. Fort Devens, Massachusetts. Prepared for the U.S. Army Environmental Center (AEC). June.
- Arthur D. Little, Inc. (ADL), 1994b. Addendum 1 - AREE River Evaluation. Base Realignment and Closure Environmental Evaluation. Fort Devens, Massachusetts. Prepared for the U.S. Army Environmental Center (AEC). Rev 2 June.

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REFERENCES

- ATEC Environmental Consultants (ATEC), 1992. "Post-Removal Report, Underground Storage Tank Closure, 5,000 Gallon Gasoline, UST No. 0112, Building 2446, Fort Devens, Massachusetts"; ATEC File No. 37.07.91.07451; Norwell, MA; prepared for U.S. Army Directorate of Contracting; Fort Devens, Massachusetts; September 24. [SA 43J]
- Bailey, N.J.L, A.M. Jobson, and M.A. Rogers, 1973. "Bacterial Degradation of Crude Oil: Comparison of field and Experimental Data"; *Chemical Geology*; Vol. II; pp. 203-211.
- Barbour, F. A., c. 1941. "Fort Devens, Mass. General Layout Plan"; Plan 6101-710.1B; prepared for Construction Division, Office of Quartermaster General; Scale approximately 1:7,000.
- Base Realignment and Closure Commission Plan (BRAC 91), 1994. PL 101-510. May 1994.
- Biang, C.A., R.W. Peters, R.H. Pearl, and S.Y. Tsai, 1992. "Master Environmental Plan for Fort Devens, Massachusetts"; prepared for U.S. Army Toxic and Hazardous Materials Agency; prepared by Argonne National Laboratory, Environmental Assessment and Information Sciences Division; Argonne, Illinois; April.
- Bouwer, H., and R.C. Rice, 1976. "Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells"; *Water Resources Research*; Vol. 12, No. 3; pp. 423-428.
- Brackley, R.A. and B.P. Hansen, 1977. "Water Resources of the Nashua and Souhegan River Basins, Massachusetts." *U.S. Geological Survey Hydrologic Investigations Atlas HA-276*.
- Cooper, H.H. and Jacob, C.E., 1946. "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History"; *Tans. Amer. Geophys. Union.*, v.27, p. 526-534.

ABB Environmental Services, Inc.

REFERENCES

- Cooper, H.H., Jr., 1963. Type Curves for Nonsteady Radial Flow in an Infiltrate Leary Artesian Aquifer; in Bentall, Ray, Compiler, Shortcuts and Special Problems in Aquifer Tests: U.S. Geol. Survey Water-Supply Paper 1545-C, pp. C48-C55.
- Detrick, C.E., 1991. "Installation Assessment, Fort Devens, Ayer, Massachusetts"; prepared for U.S. Army Toxic and Hazardous Materials Agency; prepared by Environmental Photographic Interpretation Center, Environmental Monitoring Systems Laboratory, Warrenton, VA; September.
- Driscoll, F.G., Ph.D., 1986. Groundwater and Wells; Second Edition; Johnson Division, St. Paul, Minnesota, 1986.
- Ecology and Environmental, Inc. (E&E), 1994. Final Remedial Investigations Report, Functional Area I, Fort Devens, Massachusetts (Volumes I through IV). Prepared by E&E for the U.S. Army Environmental Center (AEC). August 1994.
- Engineering Technologies Associates, Inc. (ETA), 1992. *Ground Water Flow Model at Fort Devens, Massachusetts*. Prepared for Commander, U.S. Army Toxic and Hazardous Materials Agency. Ellicott City, Maryland: ETA. October 30.
- Environmental Applications, Inc. (EA), 1990. "Ft. Devens Tank Replacement Project Final Report, Contract No., DAKF-31-89-C-0761, Vol. I"; prepared for U.S. Army, Fort Devens, MA; Waltham, MA; September.
- Environmental Criteria and Assessment Office (ECAO), 1994a. "Oral Toxicity Assessment for Cobalt, U.S. Environmental Protection Agency, Technical Support Center (TSC), Cincinnati, Ohio, November 7, 1994.
- Environmental Criteria and Assessment Office (ECAO), 1994c. "Risk Assessment Issue Paper for: Provisional for Naphthalene (91-20-3)"; U.S. Environmental Protection Agency, Technical Support Center (TSC).

ABB Environmental Services, Inc.

REFERENCES

- Fetter, C.W., 1988. *Applied Hydrogeology*; Merrill Publishing Company, Columbus, Ohio.
- Fort Devens Dispatch*, 1992. "The Army in New England: 75 Years in the Making." Special Edition. Vol. 52, No. 34. September 10.
- Freeze, 1979. Freeze, R. Allan, J. A. Cherry, 1979. *Groundwater*: Englewood Cliffs, N.J., Prentice Hall, p. 29.
- GZA Remediation, Inc. (GZAR), 1990. "Tank Replacement Project, Fort Devens, Massachusetts, Modification p00003, Hydrogeological Investigation, Contract No., DAKF-31-89-C00761"; prepared for U.S. Army, Fort Devens, MA; Waltham, MA; October.
- Huling, S.G. 1989. "Facilitated Transport"; EPA/540/4-89/003, 5 p.
- Hvorslev, M.J., 1951. "Time Lag and Soil Permeability in Groundwater Investigations"; U.S. Army Corps of Engineers Waterways Experiments Station; Bulletin 36; Vicksburg, MS.
- Jahns, R.H., 1953. *Surficial Geology of the Ayer Quadrangle, Massachusetts*. Scale 1:31,680. U.S. Geological Survey.
- Jamison, V.W., R.L. Raymond, and J.O. Hudson, 1975. "Biodegradation of High Octane Gasoline in Groundwater"; *Developments in Industrial Microbiology*; Vol. 16; pp. 305-311.
- Jenkins, & Prentice, "Theory for Aquifer Test Analysis in Fractured Rocks Under Linera (Nonradial) Flow Conditions Groundwater"; Vol. 20, No. 1, pp. 12-21, 1982.
- Keely, J.F. 1989. "Performance Evaluations of Pump-and-Treat Remediations"; U.S. EPA/540/4-89/005. 19 p.

ABB Environmental Services, Inc.

REFERENCES

- Kenaga, S.E., and C.A.I. Goring, 1978. "Relationship Between Water Solubility, Soil Sorption, Octanol-Water Partitioning, and Bioconcentration of Chemicals in Biota"; American Society of Testing Material; Third Aquatic Toxicity Symposium; New Orleans, Louisiana; p. 63.
- Koteff, C., 1966. "Surficial Geologic Map of the Clinton Quadrangle, Worcester County, Massachusetts." U.S. Geological Survey Map GQ-567.
- Kurz Associates, Inc., 1991. "Underground Storage Tank Removal and Related Environmental Investigations, Fort Devens Military Reservation, Harvard, Massachusetts"; prepared for Franklin Environmental Services, Inc., Wrentham, MA; Bridgewater, MA; January.
- McMaster, B.N., J.D. Bonds, J.H. Wiese, K.L. Hatfield, J.B. Holly, L.C. Carter, E.A. Knauff, and K.A. Civitarese, 1982. *Installation Assessment of Headquarters Fort Devens, Report No. 326*. Prepared for Commander, Headquarters Fort Devens and for U.S. Army Toxic and Hazardous Materials Agency. Prepared by Environmental Science and Engineering, Inc.. Gainesville, FL. August.
- Marcoa Publishing, Inc., 1990. "Welcome to Fort Devens - A Community of Excellence." San Diego, California.
- Massachusetts Department of Environmental Protection, 1993a. "Drinking Water Standards and Guidelines for Chemicals in Massachusetts Drinking Waters"; Office of Research and Standards, Boston, MA. Autumn 1993.
- Massachusetts Department of Environmental Protection, 1993b. "Revised Massachusetts Contingency Plan, 310 CMR 40.000. Autumn 1993.
- Massachusetts Department of Environmental Protection (MADEP), 1995. "Massachusetts Contingency Plan"; Office of Environmental Affairs, Boston, Massachusetts, January 1995.
- Montgomery, J.H., 1991. "Groundwater Chemical Field Guide". Lewis Publishers, Chelsea, MI. 271 p.

ABB Environmental Services, Inc.

REFERENCES

- Nobis Engineering, Inc., 1990. "Underground Tank Removal, Fort Devens Military Reserve, Fort Devens, Massachusetts"; prepared for Advanced Petroleum Products, Inc.; Concord, NH; December.
- Nobis Engineering, Inc., 1991. "Subsurface Investigation, Building P-2008, Fort Devens Military Reserve, Fort Devens, Massachusetts"; prepared for Advanced Petroleum Products, Inc.; Concord, NH; July 2.
- Peck, J.H., 1975. "Preliminary Bedrock Geologic Map of the Clinton Quadrangle, Worcester County, Massachusetts." Scale 1:24,000; text and three maps. U.S. Geological Survey Open-File Report 75-658.
- Peck, J.H., 1976. "Silurian and Devonian Stratigraphy in the Clinton Quadrangle, Central Massachusetts." In *Contributions to the Stratigraphy of New England*. Geological Society of America Memoir 148.
- Potomac Research Inc. (PRI), 1993. *User's Manual, IRDMIS PC Data Entry and Validation Subsystem*. Version 5.0. Prepared for U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland. February.
- Robinson, G.R., Jr., 1978. "Bedrock Geologic Map of the Pepperell Shirley, Townsend Quadrangles, and Part of the Ayer Quadrangle, Massachusetts and New Hampshire." Miscellaneous Field Studies Map MF-957. U.S. Geological Survey.
- Robinson, P. and R. Goldsmith, 1991. "Stratigraphy of the Merrimack Belt, Central Massachusetts." In *The Bedrock Geology of Massachusetts*. U.S. Geological Survey Professional Paper 1366-G. pp. 61-637.
- Russell, S.L. and R.W. Allmendinger, 1975. "Interim Geologic Map of the Shirley Quadrangle, Massachusetts." U.S. Geological Survey Open File Report 76-267.
- Sen, Zerâi, 1988. "Dimensionless Time-Drawdown Plots of Late Aquifer Test Data"; Groundwater, Vol. 26, No. 5, Sep.-Oct. 1988; pp. 615-618.

ABB Environmental Services, Inc.

REFERENCES

- Soil Conservation Service, undated. "General Soil Map of Middlesex County, Massachusetts"; U.S. Department of Agriculture; Middlesex Conservation District; unpublished.
- Soil Conservation Service, 1985. "Soil Survey of Worcester County, Massachusetts, Northeastern Part"; U.S. Department of Agriculture.
- Soil Conservation Services, 1989. Untitled Middlesex County field sheet #19; U.S. Department of Agriculture; Middlesex Conservation District; January 5.
- Soil Conservation Service, 1991. "Middlesex County Massachusetts Interim Soil Survey Report"; U.S. Department of Agriculture; Middlesex Conservation District; Westford, MA (includes Soil Sheet #19).
- Tinsley, I.J., 1979. *Chemical Concepts in Pollutant Behavior*; John Wiley and Sons; New York, New York.
- Todd, D.K., 1980. *Groundwater Hydrology*; University of California, Berkeley and David Keith Todd, Consulting Engineers, Inc.; John Wiley & Sons, New York, New York. 1980.
- U.S. Army Environmental Center (USAEC), 1987. "Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports"; March 1987.
- U.S. Army Environmental Center, 1990. "Quality Assurance Manual"; Aberdeen Proving Ground, MD; January.
- U.S. Army Environmental Center (USAEC), 1990. "USAEC QA Program"; January 1990.
- U.S. Army Environmental Center, 1993. *Fact Sheet: Fort Devens Installation Restoration Program (IRP) and BRAC 91 Environmental Restoration Impact*. March.

ABB Environmental Services, Inc.

REFERENCES

- U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), 1990. *Quality Assurance Program*. PAM-41. January.
- U.S. Department of the Army, 1979. *Environmental Impact Statement, Fort Devens Mission Activities, Fort Devens, Massachusetts*. Headquarters, U.S. Army Forces Command. June 30; Revised May 1, 1980.
- U.S. Engineer Office, 1952. "Master Plan, Fort Devens, Ayer, Mass., Detail Site Plan, Building Use Map"; Sheets Nos. 6 through 21; Boston, MA; Files X100-109/705 through X100-109/720.
- U.S. Environmental Protection Agency (USEPA) Region I and the U.S. Department of the Army, 1991e. *In the Matter of: The U.S. Department of the Army, Fort Devens Army Installation, Fort Devens, Massachusetts*. Federal Facility Agreement Under the Comprehensive Environmental Response, Compensation, and Liability Act, Section 120. May 13.
- U.S. Environmental Protection Agency (USEPA), 1983. *Guidelines for Deriving Numerical Water Quality Criteria for the Protection of Aquatic Life and Its Uses*. Draft. July.
- U.S. Environmental Protection Agency (USEPA), 1984. "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring"; OWRS; QA-1; May 1984.
- U.S. Environmental Protection Agency (USEPA), 1986. *Quality Criteria for Water 1986*. Office of Water Regulations and Standards, Washington, D.C., EPA 440/5-86-001. May 1, 1986.
- U.S. Environmental Protection Agency (USEPA), 1986. *Superfund Public Health Evaluation Manual*. Exhibit C-1.
- U.S. Environmental Protection Agency, 1988b. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA"; USEPA Office of Emergency and Remedial Response, EPA/540/G-89/004, OSWER Directive 9355.3-01; October.

ABB Environmental Services, Inc.

REFERENCES

- U.S. Environmental Protection Agency (USEPA), 1989a. "Transport and Fate of Contaminants in the Subsurface". EPA/625/4-89/019, 148 p.
- U.S. Environmental Protection Agency (USEPA), 1989b. "Risk Assessment Guidance for Superfund". Volume I: Human Health Evaluation Manual. Interim Final. OSWER Directive 9285.7-01a. September 29, 1989. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89/001.
- U.S. Environmental Protection Agency (USEPA), 1989d. Exposure Factors Handbook. Office of Health and Environmental Assessment, Washington, D.C. July.
- U.S. Environmental Protection Agency (USEPA), 1990b. "Basics of Pump-and-Treat Groundwater Remediation Technology"; Environmental Research Laboratory, Ada, OK, EPA/600/8-90/003.
- U.S. Environmental Protection Agency (USEPA), 1991. "National Functional Guidelines for Organic Data Review"; Washington, D.C.
- U.S. Environmental Protection Agency (USEPA), 1991b. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual Supplemental Guidance. Standard Default Exposure Factors. Interim Final. Washington, D.C. OSWER Directive 9285.6-03. March 25, 1991.
- U.S. Environmental Protection Agency (USEPA), 1991c. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). Publication 9298.7-013. December 1991 and Revision October 1992.
- U.S. Environmental Protection Agency (USEPA), 1992b. Guidelines for Exposure Assessment. Federal Register 57:22888-22938.
- U.S. Environmental Protection Agency (USEPA), 1992c. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Solid Waste and Emergency Response. Publication 9285.7-081. May 1992.

ABB Environmental Services, Inc.

REFERENCES

- U.S. Environmental Protection Agency (USEPA), 1992d. Dermal Exposure Assessment: Principles and Applications. Interim Report. Office of Research and Development. EPA/600/8-91/011B. January.
- U.S. Environmental Protection Agency (USEPA), 1993. Data Quality Objective Process for Superfund, Interim Final Guidance, EPA/540/G-93/071, Publication 9355.9-01, September 1993.
- U.S. Environmental Protection Agency (USEPA), 1993a. "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons." EPA/600/R-93/C89. July 1993.
- U.S. Environmental Protection Agency (USEPA), 1993a. Risk-Based Concentration Table, Fourth Quarter 1993. Prepared by Roy L. Smith, USEPA Region III Technical Support Section. October 15, 1993.
- U.S. Environmental Protection Agency (USEPA), 1993b. Drinking Water Regulations and Health Advisories. Office of Water, Washington, DC. May 1993.
- U.S. Environmental Protection Agency (USEPA), 1994a. Region I Update from Mike Murphy.
- U.S. Environmental Protection Agency (USEPA), 1994b. "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities"; Office of Solid Waste and Emergency Response' OWSER Directive 355.4-12; July 1994.
- U.S. Environmental Protection Agency (USEPA), 1994c. "Health Effects Assessment Summary Tables (HEAST)", Annual FY 1994. Office of Solid Waste and Emergency Response EPA/540/5-94/020, and the July 1994 and November 1994 Supplemental Updates.
- U.S. Environmental Protection Agency (USEPA), 1995a. "Integrated Risk Information System (IRIS); On-Line Service.

ABB Environmental Services, Inc.

REFERENCES

- U.S. Environmental Protection Agency (USEPA), 1995b. Region III Risk-Based Concentration Table, January - June 1995. Roy L. Smith, Ph.D., Senior Toxicologist, Technical Support Section (3HW13), 841 Chestnut Street, Philadelphia, Pennsylvania 19107, March 7, 1995.
- U.S. Fish and Wildlife Service (USFWS), 1992. "Survey and Evaluation of Wetlands and Wildlife Habitat, Fort Devens, Massachusetts. House of Representatives Appropriations Committee. p. 1 - 10.
- Vanasse Hangen Brustlin, Inc., 1994. Devens Reuse Plan. Prepared for the Boards of Selectmen of the Towns of Ayer, Harvard, Lancaster, and Shirley and the Massachusetts Government Land Bank. November 14, 1994.
- Walton, W.C., 1988. "Practical Aspects of Groundwater Modeling". 3rd Edition. NWWA, 587 p.
- Wones, D.R. and R. Goldsmith, 1991. *Intrusive Rocks of Eastern Massachusetts*. U.S. Geological Survey Professional Paper 1366-I.
- Zen, E-an, Ed., 1983. "Bedrock Geologic Map of New England." U.S. Geological Survey; Scale 1:250,000; three sheets.

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